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Effect of sweet orange *(Citrus sinensis)* peel meal (SOPM) on the growth performance, carcass attributes and economics of production of rabbits

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ABSTRACT

The increase in demand; the consequential high cost of maize (which is a conventional source of dietary energy for rabbit) and its resultant high cost of production of rabbits necessitates investigation into unconventional alternatives. Sweet Orange Peel Meal (SOPM) which has high energy content was tested on the growth performance, carcass attributes and economics of production of rabbits. Fifty (50) weaner rabbits of mixed breeds, sexes and average weight of 0.5kg were fed graded levels of SOPM in place of maize in their diets for 56days. They were randomly allocated into five dietary treatments of SOPM replacing maize at 0, 25, 50, 75 and 100% with ten replicates per treatment in a Completely Randomized Design. There existed not significant (P>0.05) difference in the Final Body Weight (976.00-1166.67g), Total Feed Consumed (3170.00-3255.00g), and Feed Conversion Ratio (4.46-5.49) of the rabbits at the end of the experiment. However, the percentage dressed weight of rabbits fed 75 and 100% (70.09 and 68.86%

respectively) and thigh weights of rabbits fed 50, 75 and 100% inclusion of SOPM (208.78, 220.31 and 207.86g respectively)were significantly (P<0.05) higher compared to the remaining treatments. The average loin and pelt weight of rabbits fed 75% SOPM (126.62g and 125.28g respectively) were significantly (P<0.05) higher compared to other treatments. Shoulder weight of rabbits fed 75 and 100% SOPM (143.81g and 140.95g respectively) were significantly (P<0.05) higher compared to the other treatments. No significant (P>0.05) difference existed among treatments in terms of Slaughter weight (966.67g-1166.67g), Carcass Yield (39.81-58.77%), Carcass Length (282.30-302.30mm), Ribs (33.17-51.20g), Neck (15.36-24.26g), Head (98.13-122.13g), Limbs (23.58-29.77g) and Tail (3.62-6.73g).The cost of rabbit feed (₦)/kg decreases from 0-100% SOPM (₦101.82-₦80.62). The least cost of feed (₦)/kg weight gain was recorded at 75% (₦390.31). However, inclusion levels at 25% (558.18), 50% (₦487.82) and 100% (₦405.62) also recorded lower cost values than the control diet 0% (₦633.20). The cost of weight gain (₦) also decreases from 0-100%SOPM (₦348.26-₦259.60). At 75% inclusion of SOPM, the least total cost of production (₦1,365.31) and highest percentage cost benefits (38.36%) were recorded over other treatments in this experiment. The study however reveals that SOPM can be used to replace maize in the ration of rabbit up to 100% with optimum performance recorded at 75%.

Keywords: Carcass attributes, Growth performance, Sweet Orange Peel Meal, Rabbits

1. INTRODUCTION

The shortage in the production and supply of animal protein sources in developing countries; the ever increasing demand for animal protein; the continuous extemporaneous competition between man and livestock for the consumption of some feedstuffs; the increase in demand for the limited production and supply of the feedstuffs and the consequential increase in the prices of the finished feeds are enough reasons to find alternative for these materials in the diet of livestock.

The main challenge in this context is the need for the supply of sufficient animal protein intake especially in developing countries and this problem is further complicated by the ever increasing population who depend on the limited supply of crops which are also important in compounding feed for livestock (Michael *et al.*, 2012). According to Ogunsipe and Agbede (2012), the insufficient supply of feedstuffs and the high cost of the ones available continue to plague sufficient production, supply and consumption of animal protein in the diet of man especially in third world countries like Nigeria. There is, however, the need to source for feed ingredients that can be substituted for these conventional feed ingredients with the aim of reducing the cost of feed production and subsequently, the total cost of production of livestock (Ojabo *et al.,* 2012). The alternative feed ingredients, however, would serve their purpose if they are of negligible or no cost; confers similar or even better effect on the growth and development of livestock; must be readily available and should not be the type that both man and animal consume as food (i.e. preferably a by-product of human food).

Rabbit production plays an important role in tackling the problem of protein malnutrition in developing countries. The advantages of rabbit production include the potential of rabbit meat as a good quality food owing to its higher protein contents, lower fat, lower sodium and cholesterol contents compared with other meat sources such as beef, pork, mutton and chickens; and the fact that rabbits, over other monogastrics, have the ability to thrive on green forage, food wastes and agricultural by-products (Aderemi and Wuraola, 2010). Rabbit production in Nigeria is yet to assume commercial production scale comparable to poultry. Reports on the sources of animal protein show that the best potential of bridging the animal protein gap in the country within the shortest time possible hangs on the expansion of rabbit production (Bamidele and Ikhatua, 2000). However, the greatest limiting factor in achieving thisis the inadequate provision of cheap and affordable feedowing to the competition between man and livestock for conventional feedstuffs like maize, soybean and groundnut (Whittermore, 1994).

The most important conventional energy-source feedstuff in the feed of rabbits and other important monogatrics remains maize. The numerous uses of maize for human consumption, as animal feed and as input in other industrial activities has made its demand overly high with a consequential rise in price and hence, resulting into high production cost of livestock (Aderemi and Wuraola, 2010). The supplementation with under-utilized unconventional feedstuffs such as grain by-products like; maize offal, rice bran, corn cob, wheat bran etc., which serves as fibre and energy sources for livestock are unfortunately becoming scarce and expensive. There is therefore the need to search for other alternatives. The potential alternative feedstuff that was investigated in this study is Sweet Orange Peel Meal.

Sweet Orange Peel; a waste product of sweet orange is abundant in areas populated with orange sellers and juice-canning industries in Nigeria; have no direct human use; cost less; and can be considered as wastes on the streets of Nigeria where they are usually noticed along major roads because the government and orange retailers have no strategic disposal programme, and hence becoming an environmental hazard (Oluremi *et al.*, 2007). Sweet orange is grown in more than 125 countries; hence its production is

worldwide (Wardowski *et al.,* 1986). The reported chemical compositions of the dried Sweet Orange Peel Meal (Oluremi *et al.*, 2007) are; 89.65% Dry Matter, 10.74% Crude Protein, 7.86% Crude Fibre, 12.60% Ether Extract, 11.90% Ash and 56.89% Nitrogen Free Extract. The comparable nutrient density with maize makes it a better alternative in livestock feed formulation. This study was designed to investigate the growth performance and carcass attribute of rabbits fed Sweet Orange Peel Meal (SOPM) in replacement for maize in their diets.

2. MATERIALS AND METHODS

Experimental Site

The experiment was carried out at the Rabbitry Unit of the Teaching and Research Farm, Adeyemi College of Education Ondo in Ondo state, South-western, Nigeria. The study area is located between the Latitude 7˚1 ' N and Longitude 4˚83 ' E (Maps-street view, 2015). Ecologically, the area lies in the rain forest zone with two raining seasons from February to July and September to November.

Experimental Animals and their Management

Fifty (50) weaned rabbits of mixed sexes and breeds with an average initial weight of 0.6kg were used for the feeding trial. The animals were housed in a large wooden wire mesh cage. The cages were further partitioned into mini cages such that each hutch consists of one rabbit. The cages were arranged in a pen whose dwarf wall was made of blocks as a base and the upper part made of wire mesh to permit free flow of ventilation and the pen was roofed with iron sheet. The animals were weighed and randomly distributed to five dietary treatments of ten replicates per treatment in a Completely Randomized Design (CRD) at the end of an acclimation period of two weeks.

Collection and Processing of Test Ingredient

Sweet orange peel was gathered from an area populated with sweet orange sellers in Ondo town, Nigeria. The peel was air-dried for fourteen days to reduce the moisture content. The dried product was hammer milled to obtain a meal called Sweet Orange Peel Meal (SOPM).

Table 1 Composition of Experimental Diets

Ingredients (%)	**SOPM Inclusion Levels (%)**				
	0	**25**	**50**	**75**	**100**
Maize	32	24	16	8	-
SOPM	-	8	16	24	32
Soya Bean Meal	9	9	9	9	9
Bone Meal	3.5	3.5	3.5	3.5	3.5
Wheat Offal	6	6	6	6	6
Fish Meal	5	5	5	5	5
P.K.C.	16.5	16.5	16.5	16.5	16.5
Corn Bran	27.5	27.5	27.5	27.5	27.5
*Premix	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Calculated Nutrients					
Crude protein	17.72	17.93	17.95	17.96	17.97
Crude fibre	11.02	11.48	11.93	12.39	12.84
Ether Extract	7.38	8.12	8.87	9.61	10.34
Nitrogen Free Extract	55.37	53.35	51.34	49.32	47.30
Metabolizable energy (KCal/Kg)	3,189.52	3,180.01	3,165.03	3,148.52	3,131.19

**Premix contents per kg: vitamins A 10000IU, vitamin B 2000IU, vitamin E 13000IU, vitamin K 1500mg, vitamin B12 10mg, Riboflavin 500mg, Pyridoxine 1300mg, Thiamine 1300mg, Panthothenic acid 800mg, Nicotinic acid 2800mg, Folic acid 500mg, Biotin 400mg, Copper 700mg, Manganese 4800mg, Iron 5800mg, Zinc 5800mg, Selenium 129mg, Iodine 60mg, Cobalt 300mg, Chlorine 27500mg.*

Experimental Diets

Five experimental diets were formulated such that maize was replaced with Sweet Orange Peel Meal at inclusion levels 0, 25, 50, 75 and 100% for diets 1, 2, 3, 4 and 5 respectively and were fed to animals *ad-libitum* throughout the experimental duration with clean cool water supplied at all times.

Feeding and Routine Management

The experiment lasted for a period of 56 days (8 weeks). The initial weights of the rabbit were taken before distributing them into their different cages. The rabbits were subjected to two (2) weeks adaptation period during which grower's mash was given to the animals and water served at all times. The weight of feed given and the weight of leftover were record on a daily basis so as to estimate feed intake during the experimental period. The animals were weighed weekly throughout the experimental period. The floor of the pen cages was cleaned daily.

Parameters measured

At the end of the 8th week, 6 rabbits were randomly selected from each treatment and weighed. They were starved over-night to clear the gut and thereafter weighed. The selected animals were stunned and slaughtered and the cut parts were measured or weighed. The final live weight, slaughter weight, dressed weight, carcass yield and intestine plus content were weighed using a sensitive scale but the carcass length was measured with thread on ruler. The weight of the lungs plus trachea, heart, kidney, kidney fat, liver, pancreas, bile, thigh, loin, ribs, neck, shoulder, head, limbs, pelt and tail were weighed using a sensitive scale.

For the growth performance, the Weekly Weight Gain was determined by subtracting preceding recorded weight from the present weight. In term of the Total Weight Gain, the Final Live Weight was subtracted from the Initial Body Weight while the Average Weight Gain was calculated by dividing the Total Weight Gain by the duration of the experiment in days (TWG/56days).Total Feed Consumed was calculated by adding the Daily Feed Consumed per rabbit for the 56days of experimentation. Feed Conversion Ratio was calculated using this formula:

$$\text{Feed Conversion Ratio} = \frac{\text{Daily Feed Consumption}}{\text{Daily Weight Gain}}$$

Statistical and Economic Analyses

Data collected on the growth performance and carcass attribute and relative organ weights were analyzed using Analysis of Variance (ANOVA). Where differences were significant, the means were separated using Duncan Multiple Range Test (DMRT) of the statistical software package SPSS (2002).

The economic evaluation of rabbit production was carried out using the as following economic tools:

$$\text{Cost of weight gain (₦)} = \text{Average weight gain (kg) x Cost of feed ₦/kg weight gain}$$

$$\text{Cost of feed (₦)/kg weight gain} = \frac{\text{Cost of feed (₦/kg)x Average feed consumed(kg)}}{\text{Average weight gain (kg)}}$$

$$\text{Relative Cost Benefit (\%)} = \frac{\text{Cost of feed ₦/kg weight gain of control diet} - \text{Cost of feed ₦/kg weight of test diet}}{\text{Cost of feed₦/kg weight gain of control diet}} \times 100$$

$$\text{Total Cost (₦)} = \text{Total fixed cost (TFC)} + \text{Total variable cost (TVC)}$$

$$\text{Cost differential} = \text{Cost of feed ₦/kg weight gain of control} - \text{Cost of feed ₦/kg weight gain of test diet}$$

3. RESULTS AND DISCUSSION

Results

Table 2 Growth Performance of Growing Rabbits fed Diets of Maize Replaced with Sweet Orange Peel Meal

Parameters	SOPM Levels of Inclusion (%)					SEM	Sig
	0	25	50	75	100		
Initial Body Weight (g)	416.67	532.33	450.00	456.67	466.00	68.72	0.661
Final Live Weight (g)	966.67	976.00	1066.67	1166.67	1110.00	84.98	0.412
Total Weight Gain (g)	550.00	592.67	616.67	710.00	644.00	125.83	0.518
Daily Weight Gain (g)	9.82	10.58	11.55	12.68	11.50	2.25	0.579
Total Feed Consumption (g)	3230.00	3255.00	3206.67	3170.00	3221.67	73.30	0.877
Daily Feed consumption(g)	57.68	58.13	57.26	56.61	57.53	1.33	0.894
Feed Conversion Ratio	5.87	5.49	4.96	4.46	5.00	2.63	0.735
Mortality (%)	0.00	0.00	0.00	0.00	0.00	0.00	

SEM: Standard Error of Mean

The result of growth performance of rabbits fed maize replaced with sweet orange peel meal diet is as presented in Table 2. The results show that there was no significant (P>0.05) difference in the final live weight, total weight gain, daily weight gain, total feed consumption, daily feed consumption, percentage mortality and feed conversion ratio of rabbits fed dietary inclusion of SOPM in place of maize. These indicate that the inclusion of Sweet Orange Peel in the diets of rabbits did not have any negative effect on the growth performance of rabbits. However, it is worthy to note that weight gain increase numerically with successive inclusion of SOPM and highest (12.68%) at 75% level of inclusion while at 75% inclusion level feed consumption was lowest (i.e. 56.61g).

Table 3 Carcass Characteristics of Growing Rabbits fed Diets of Maize Replaced with Sweet Orange Peel Meal

Parameter	SOPM Levels of Inclusion (%)					SEM	Sig
	0	25	50	75	100		
Slaughter Weight (g)	966.67	966.67	1066.67	1166.67	1150.00	86.424	0.395
Percentage Dressed Weight (%)	69.19^{b}	65.67^{ab}	66.06^{ab}	70.09^{a}	68.86^{a}	7.068	0.042
Carcass Yield (%)	39.81	43.89	45.75	58.77	54.81	5.711	0.233
Thigh (g/kg)	162.13^{b}	182.29^{ab}	208.78^{a}	220.31^{a}	207.86^{a}	24.029	0.032
Loin (g/kg)	87.49^{bc}	77.08^{c}	118.73^{ab}	126.62^{a}	105.56^{abc}	9.092	0.022
Carcass Length (mm)	286.00	302.30	282.30	288.00	295.00	0.554	0.179
Ribs (g/kg)	35.85	33.17	48.02	51.20	38.86	9.015	0.624
Neck (g/kg)	15.36	14.50	19.62	22.73	24.26	3.794	0.389
Shoulder (g/Kg)	105.72^{b}	98.74^{b}	126.94^{ab}	143.81^{a}	140.95^{a}	8.934	0.027
Head (g/kg)	98.13	95.54	113.81	122.13	115.25	9.313	0.304
Limbs (g/kg)	24.48	23.58	28.76	29.69	29.77	2.471	0.324
Pelt (g/kg)	86.23^{bc}	74.25^{c}	111.24^{abc}	125.28^{a}	115.98^{ab}	10.866	0.040
Tail (g/kg)	3.62	3.95	6.73	5.17	6.02	1.464	0.396

^{a,b,c}: Mean values with different superscript along the same row indicate significant difference (P<0.05)

SEM: Standard Error of Mean

The result of the carcass attributes of rabbits fed maize replaced with sweet orange peel meal is as presented in Table 3. The percentage dressed weight of rabbits fed 75 and 100%inclusion levels of SOPM(i.e. 70.09 and 68.86% respectively) are significantly(P<0.05) higher when compared with those fed 0% inclusion level. The thigh weights of rabbits fed 50, 75 and 100% inclusion levels of SOPM are significantly (P<0.05) higher when compared with those fed maize based diet. For loin weights, rabbits fed 75% are significantly higher (P<0.05) compared with the lowest value (77.08g) in those fed 25%.For the weight of shoulders, rabbits fed 75 and 100% inclusion levels have significantly higher (P<0.05)weights when compared with those on 0 and 25%. The pelt of rabbits fed 75% and 100% SOPM were significantly higher (P<0.05) when compared with rabbits fed 25% inclusion level of SOPM.

However, no significant difference (P<0.05) existed among slaughter weights, carcass yield and carcass length of rabbits across the treatments. Likewise for the weights of ribs, neck, head, limbs and tail of the rabbits were not significant (P>0.05) irrespective of dietary inclusion of SOPM.

Table 4 Economics of Production of Rabbits fed Diets of Maize Replaced with Sweet Orange Peel Meal

	SOPM Levels of Inclusion (%)				
	0	**25**	**50**	**75**	**100**
Initial Weight (g)	416.67	532.33	450.00	456.67	466.00
Purchase Price (₦)	697.00	722.00	715.00	725.00	730.00
Average Weight Gain (kg)	0.55	0.59	0.62	0.71	0.64
Average Feed Consumed (kg)	3.23	3.26	3.21	3.17	3.22
Cost Items					
Cost of Cage Maintenance (₦)	250	250	250	250	250
Cost of Feed (₦/kg)	107.82	101.02	94.22	87.42	80.62
Cost of Feed (₦)/kg Weight Gain	633.20	558.18	487.82	390.31	405.62
Cost of Weight Gain (₦)	348.26	329.33	302.44	277.12	259.60
Total Cost (₦)	1580.20	1530.18	1452.82	1365.31	1385.62
Cost Differential	-	75.02	145.38	242.89	227.58
Relative Cost Benefit (%)	-	11.85	22.96	38.36	35.94

Table 4 reveals the result of the calculated values of parameters used in measuring the economics of production of growing rabbits fed diets of maize replaced with sweet orange peel meal. The total cost of production and the percentage relative cost benefit at the end of the experiment reveals that it is economical to produce rabbits using SOPM to replace maize in their diet. However, at 75% inclusion, it is more economical than the other inclusion levels.

4. DISCUSSION

The nutrient composition of the experimental diets as shown in Table 1 revealed that the Crude protein content of the test diets which ranged from (17.72-17.97%), Crude Fibre (11.02-12.84%), Ether Extract (7.38-10.34%), Nitrogen Free Extract (46.66-53.37%) and Metabolizable Energy (3,131.10-3,189.52Kcal/Kg) are within the recommended values for rabbits raised in the tropics (Champe and Maurice, 1993; NRC, 1994). The inclusion of SOPM at graded level to replace maize in the diet of rabbits as done in this experiment increased the overall Crude Protein (17.93-17.97%), Crude Fibre (11.48-12.84%) and Ether Extract (8.12-10.34%)over those of the control diet (17.72%, 11.02% and 7.38% respectively). Meanwhile, Nitrogen Free Extract (46.66-53.19%) and Metabolizable Energy (3,131.10-3,180.01Kcal/Kg) were lower among treatments fed test diets over control (55.37% and 3,189.52 Kcal/Kg respectively). However, the comparable nutrient composition in the experimental diets could be ascribed to the similar nutrient density of sweet orange peel and maize.

The results of the similar feed consumption in this study show that the percentage Crude fibre of SOPM (i.e. 12.60%) which is higher than that of maize (7.3%) according to Nuss and Tanumihardjo, 2010) and had increased the overall CF% (11.48-12.84%)of the test diets compared to the control (11.02%) has not significantly influenced (P>0.05) the TFC of the rabbits. This contradicts the report by Adeniyi (2003) whose opinion was that increase in %CF will lead to increase in TFC of rabbits but similar to that of Ayoola and Adedeji (2014) who reported that increase in crude fibre has no influence on TFC after replacing maize with sundried rice straw meal in rabbit diets. Also, the Daily Feed Consumed in this study (56.61g-58.13g) is less than that of Ojebo *et al.* (2012) (61.97g-67.19g) who also replaced maize with SOPM up to 40% in the diets of rabbits. This variation can be attributed to the difference in the initial weight of rabbits in this study (416.07g-532.33g) and that of Ojabo *et al.* (2012) (760.00g-780.00).

The similar final, total and daily weight gains among rabbits in the different treatment groups informs that the replacement of maize with SOPM has no negative effect on the growth performance of rabbits. This report is similar to that of Ojabo *et al.* (2012) who also reported no significant difference (P>0.05) in the final live weight (g) and body weight gain (g/day) after replacing maize with SOPM in the diet of rabbits up to 40% and Olagunju (2001) who replaced maize with sundried cassava peel meal in growing rabbit diet but contrary to that of Yang and Chung (1985) who reported that there existed significant difference (P<0.05) in the performance of broiler chickens as the weight gain and feed intake were negatively affected as the level of citrus meal in poultry diet increased. The average daily weight gains recorded (i.e. 9.82-12.68g) are in agreement with the range of 10-20g as reported by Owen (1976) and Adenkola *et al.* (2009) for rabbits in the tropics.

The non-significant (P>0.05) difference in the Feed Conversion Ratio (FCR) among rabbits on the different treatment groups (4.46-5.87) reveals that replacing maize with SOPM in the diets of rabbits has no negative effect on their FCR and this report is similar to that of Ojabo *et al.* (2012) who replaced maize with SOPM up to 40% in the diet of rabbits and Oluremi *et al.* (2005) who replaced maize with sweet orange rind up to 15% in broiler diet.

The absence of significant (P>0.05) difference in the slaughter weight and carcass length in this study is similar to rabbits fed up to 40% SOPM (Ojabo *et al.,* 2012) and dietary inclusion of breadfruit meal (Abimbola *et al.,* 2010) respectively. However, the significant difference (P<0.05) which existed among treatments on the percentage dressed, thigh, loin, shoulder and pelt weights are in agreement with the report by Lebas and Laplace (1991) who opined that variation in nutritional status and requirement of growing rabbits modify the anatomical equilibrium of the carcass, composition of carcass tissues and components of the muscle.

The economics of production of growing rabbits fed diets of maize replaced with sweet orange peel meal as shown in Table 4 reveals that the cost of rabbit feed (₦/kg) decreases steadily with a successive increase of SOPM in place of maize in the diets of rabbits (i.e. ₦101.82-₦80.62). The cost of feed (₦/kg) weight gain however differ in its relationship with the inclusion levels of SOPM. At 75%, the least cost of feed (₦/kg) weight gain was recorded (₦390.31) as against the highest cost recorded at 0% (control) inclusion level (₦633.20). The cost of weight gain (₦) also decreases steadily with a gradual increase in the inclusion of SOPM in rabbit feed from 0-100% (i.e. ₦348.26-₦259.60). The total cost of production of rabbits at 75% inclusion of SOPM (₦1,365.31) is the least cost of production recorded over other treatments in this experiment. Likewise, the percentage cost benefits at 75% inclusion of SOPM (38.36%) in the diet of rabbits appear to be the highest over other treatments. This reveals that it is more economical to produce rabbits using 75% inclusion of SOPM in replacing maize in their diets than other inclusion levels.

5. CONCLUSION

The result of this study shows that up to 100%, maize in rabbit diet can be replaced with sweet orange peel meal with no negative effects on the performance of rabbits. As a high energy source like maize and higher protein source than maize, its inclusion in rabbit feed up to 100% would help to reduce the cost of production. However, this study further revealed that the optimum inclusion of SOPM as an alternative for maize in rabbit diet is 75% (24g/100g in the gross feed composition) using the performance, carcass and economic indices determined. It could therefore be concluded that SOPM is an excellent substitute for maize in rabbit diets and that its abundance be exploited as a significant leap to reduce the high demand and cost on maize and its consequential effect on the cost of production of rabbit.

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