

## Growth performance and economics of feeding growing rabbits with sweet orange by-products meal as alternative fibre source

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**Target audience:** Rabbit farmers, Animal nutritionist, orange farmers and fruit juice industry

### Abstract

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The study was designed to evaluate the proximate composition and the feeding value of orange waste meal as an alternative fibre source in rabbits diets. The orange waste (residue after extracting the juice) was gathered from different clusters within Calabar municipal and divided into two batches: the waste meal in the first group was sundried, while those in the second group were separated into mesocarp (the white outer part) and endocarp (the pulp) and sundried until the moisture content of 10% was achieved. The sundried orange wastes were milled and stored in airtight containers prior to chemical analysis and feed formulation. Based on the crude protein content, four experimental diets were formulated: Diet 1 contained wheat offal as a control, while diets 2–4 contained the orange endocarp, mesocarp, and whole orange waste meals, respectively. Forty rabbits of mixed sexes at about five weeks old used for the experiment were weighed and randomly distributed into four groups of ten rabbits each. Each group was randomly assigned to one of the four (4) experimental diets and fed for 12 weeks in a completely randomized design. The result showed that utilizing orange waste meal as a replacement for wheat offal in rabbits diet significantly ( $P < 0.05$ ) improved the average daily weight gain, average daily feed intake, and the feed conversion ratio. The costs of producing a kilogram of feed, the feed consumed by rabbits, and the cost per kilogram of weight gain were significantly ( $P < 0.05$ ) reduced. It was therefore concluded that the orange waste meal could replace wheat offal in the growing rabbits' diet.

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**Keywords:** orange mesocarp, orange endocarp, growing rabbit, fibre source

### Description of Problem

The past few years have witnessed rapid growth in the population of developing countries, including Nigeria, with the resultant increase in the demand for proteins of animal origin. Meanwhile, increasing the production of animal protein at a reasonable

cost to enhance the diet quality of the populace has been part of the National Agricultural Policy, and the use of micro-livestock including short-cycle animals has been suggested (1). Rabbits play an important role in the supply of animal protein to the Nigerian populace (2; 3). They are

efficient converters of feed to meat and can utilize up to 30% of crude fibre as opposed to 10% by most poultry species (4). However, rabbit production has not received the desired attention in the tropics, where the productivity is usually 50% or less of what is typical in temperate countries (1). The high cost of formulated concentrates and pelletized feeds compounded from conventional ingredients, including maize and soybean hinders an increase in the level of rabbit production in Nigeria (5). More so, the use of acceptable human food for feeding animals is unjustified (6); thus, supplementation with underutilized unconventional feedstuffs is considered. One of these is grain by-products, including maize offal, rice bran, corn cob, wheat bran, and offal, that serve as fibre sources (7). Unfortunately, most of these fibre sources are becoming scarce and expensive. For instance, the price of wheat offal and brewers dried grain has astronomically risen from one hundred thousand (N 100,000.00) naira and one hundred and twenty thousand (N120,000.00) naira respectively, per ton, to two hundred and thirty-six thousand (N 236,000.00) and two hundred and forty thousand (N 240,000.00) naira per ton. There is therefore need to search for other alternative fibre resources to replace the scarce and highly competitive wheat offal and brewer's grain. One among the sources considered is the orange waste meals. The orange waste meals, which are the residues left after juice extractions, include the peel, mesocarp (the white portion), and endocarp (the pulp). The fruit wastes, which are abundant in juice-canning industries in Nigeria, have no direct human use and can be considered waste in Nigerian farms. Sweet orange waste is also usually noticed on the

streets and along major roads in Nigeria because the government and orange retailers have no strategic disposal programme, thus becoming an environmental problem. Rather than discarding the orange wastes, they can be sun-dried and then milled in a grinding machine to a fine particle to obtain the orange waste meal, which can be included in livestock diets (8). Sweet orange is grown in more than 125 countries, and its worldwide production has increased from 24 million metric tons in 1961 to 71 million metric tons in 1990 (9). The reported chemical compositions of the orange wastes are 91.5% DM, 10% CP, 9.35% CF, 1.25 EE, 5.25 Ash, and 65% nitrogen-free extract. Sweet orange fruit rind (peel) meal has been observed to be a source of calories and protein comparable with maize (10). The peel contains oil sacs, and the oil is composed of 91–94% d-limonene and 2.0–2.1% B-myrcene as a minor constituent. Polymetholated flavones are also a class of compounds found in citrus peel and produce no negative side effects in the animals fed the polymetholated flavone-containing diets.

This study was designed to determine the proximate composition of the different sections of the orange waste meals and their feeding value as an alternative fibre source in rabbit rations.

## **Material and Methods**

### **Location of the experiment**

The chemical analysis was carried out at the Faculty of Agriculture Central Laboratory, University of Calabar, Calabar, Cross River State, while the feeding trial was conducted at the Rabbitary wing of the Animal Science Research Farm of the same Institution. The study was conducted between September 202 and January 2022.

The farm is located within latitudes 4°58.4282' and longitude E8°20.4602, with an annual precipitation of approximately 1830mm and an average temperature of 24°C to 30°C.

### **Processing of the Experimental Material**

The orange waste meal (residue after extracting juice) was gathered from different clusters within Calabar Municipality and divided into two batches: the waste meal in the first group was sundried, while those in the second group were separated into mesocarp (the white outer part) and endocarp (the pulp) and sundried. The sundried orange waste meal (mesocarp, endocarp, and the whole) was individually milled and stored in airtight containers prior to chemical analysis and feed formulation.

### **Proximate analysis**

Proximate analysis of the milled orange by-products and the wheat offal was carried out to determine the crude protein, crude fibre, ether extract, and total ash contents according to the methods of (11). Nitrogen-free extract was obtained by subtracting the total crude protein, crude fibre, ether extract ash and moisture from 100.

### **2.3 Preparation of Experimental Diets**

Four experimental diets were formulated as follows: Diet 1 (control, containing wheat offal) Diets 2, 3, and 4 had the orange endocarp meal (OEM), orange mesocarp meal (OMM), and the combination of the endocarp and mesocarp (whole orange waste meal) respectively, as replacement for wheat offal. The compositions of the diets are shown in Table 1.

### **Experimental Animals and Management**

Forty (40) unsexed, cross-breed (American Chinchilla x New Zealand) white, weaned rabbits, aged five (5) weeks old, were used for the experiment. They were individually weighed and distributed into four (4) groups of ten (10) rabbits, each on an equal weight basis. Each group was randomly assigned to one of the four dietary groups in a completely randomized design. They were individually housed in a double-tiered hutch made of wood and wire mesh, measuring 60 cm by 60 cm. The hutches were placed in an enclosed building with proper ventilation. Feed and water were offered in concrete crocks.

### **Data collection**

#### **Growth parameters**

The feed intake of each rabbit on a treatment basis was taken daily by subtracting the leftovers from the initial quantity offered. Individual feed intakes for the ten rabbits were added up to obtain the average daily feed intake for each treatment. The weights of rabbits were taken weekly on a treatment basis to obtain the average weekly weight gain. Records of average feed intake and weight gain were used to compute the feed conversion ratio. The economics of feeding the orange waste meal to rabbits were evaluated. The cost per kilogram of feed was calculated by multiplying the price of each ingredient by the quantity (kg) of ingredients used in compounding each diet. The cost of feed consumed was calculated by multiplying the cost per kilogram of feed by the kilogram of feed consumed by rabbits for each treatment. The cost per kilogram of weight gain was obtained from the ratio of the cost of feed consumed to the weight gain measured in kilograms.

### **Linear body measurements**

**Table 1.** Ingredient composition of experimental diet

<b>Ingredients</b>	<b>Diet 1</b>	<b>Diet 2</b>	<b>Diet 3</b>	<b>Diet 4</b>
Maize	47.78	47.78	47.78	47.78
Soybean meal	10.70	10.70	10.70	10.70
Palm kernel cake	10.00	10.00	10.00	10.00
Wheat offal	30.00	-	-	-
Mesocarp meal	-	30.00	-	-
Endocarp meal	-	-	30.00	-
Whole orange waste	-	-	-	30.00
*Vitamin/min. premix	0.50	0.50	0.50	0.50
Lysine	0.30	0.30	0.30	0.30
Methionine	0.20	0.20	0.20	0.20
Salt	0.50	0.50	0.50	0.50
<b>Total</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>
<b>Calculated analysis</b>				
Crude protein (%)	16.00	13.02	12.42	12.72
Metabolisable energy (Kcal/kg)	2,685	2682.25	2766.22	2724.45
Crude fibre (%)	5.61	6.21	7.71	6.81
<b>Determined analysis</b>				
Crude protein (%)	15.86	13.69	13.02	12.98
Metabolisable energy (Kcal/kg)	2697.02	2688.68	2760.34	2715.33
Crude fibre (%)	6.70	7.23	7.89	7.02

\*vitamin-mineral premix provide per kg of diet: vit A. 13,340 iu; vit. D3 2680 iu; vit E. 10 iu, vit K, 2.68 mg; calcium pantothenate, 10.68 mg; vit. B12, 0.022 mg; folic acid, 0.668 mg; choline chloride, 400 mg; chlortetracycline, 26.68 mg; manganese, 133.34 mg; iron, 66.68 mg; zinc, 53.34 mg; copper, 3.2 mg, iodine, 1.86 mg; cobalt, 0.268 mg, selenium, 0.108 mg.

Linear body measurements taken in centimeters with a meter rule were; the head length (HL), the body length (BL), the heart girth (HG), the ear length (EL), the forelimb (FL), and the hind limb length (HLL). HLL was measured from the hip; HL was taken as the distance from the nose to the point of the shoulder; and BL was taken from the shoulder to the pin bone. HG was taken as the body circumference just below the forelimbs. EL was taken as a distance from the point of attachment to the head of the tip of the ear; TL was taken as the distance from the coccygeal vertebra to the tip of the fingers; and HLL was measured from the tip joint to the tip of the toes.

#### **Carcass and internal organ**

#### **characteristics**

At the end of the feeding trial, three rabbits were randomly selected from each treatment for carcass evaluation. Animals were fasted for 18 hours, and the live weight was taken using a sensitive electronic scale before slaughtering. The animals were stunned by dislocating the neck before severing the jugular veins. The carcasses were thoroughly bled by hanging the head down through the hind leg on a rail, and then dissected and eviscerated. The weight of internal organs was taken and recorded as a percentage of the live weight. The carcasses were chilled in a freezer for twenty-four hours and re-weighed (after thawing) to determine the cold carcass weight. They

were then disassembled into wholesale cuts, and each primal part was weighed using the sensitive electronic balance. The dressing percentage was calculated by using the formula:

$$\text{Dressing percentage} = \frac{\text{Dressed carcass weight} \times 100}{\text{Live weight}}$$

### Statistical analysis:

Data collected were subjected to one-way analysis of variance (ANOVA) using procedures in statistical analytical software version 10 for Windows (2013). Differences among means were separated using Duncan multiple test of the same software.

## Results

### Proximate Composition

The result of the proximate composition of the different sections of the orange waste meal is presented in Table 2.

Among the orange by-products, the endocarp meal (OEM) recorded the highest ( $P < 0.05$ ) crude protein (CP), with the value corresponding to 6.56%, while the orange peel meal had the lowest CP value of 3.5%. The crude fibre (CF) contents were 15.50% for the orange mesocarp meal (OMM) and were significantly ( $P < 0.05$ ) higher compared to 13.10% recorded for the whole orange waste meal (WOWM) and 10.7% in the orange endocarp meal (OEM). The orange peel meal contained the highest ( $P < 0.05$ ) ether extract, ash, and nitrogen-free extract, with values corresponding to 2.25%, 3.00%, and 77.5%, respectively. The least ash content, with a value corresponding to 1.0%, was recorded in OMM, while OMM and OEM recorded the same values for the ether

extract. The wheat offal was, however, superior in its crude protein, ether extract, and ash contents relative to the orange by-products.

The percentage crude protein (CP) in the orange peel meal was lower than the 7.44% and 10.96% reported by (10) and (13) for the sweet orange peel. The CP value of the orange by-products from this study was also lower than 15.05% CP in brewers dried grain, 14.54% CP in maize processing waste, and 8.89% CP for rice offal, according to (14), but higher than 2.3% and 2.2% CP reported by (15) and (16), respectively, for the cassava root meal.

The crude fibre values (10.70–15.50%) obtained from this study were in agreement with the 13.66–14.99% reported for some citrus fruit varieties by (8). (14) reported 11.00%, 8.53%, and 20.72% as the crude fibre contents of brewers dried grain, maize serviette, and rice bran, respectively. The reports by these authors were in accordance with the findings of this investigation. The dietary implication of a high dietary crude fibre content as in the OPM is that it may limit its replacement value in the diets of monogastric animals, particularly poultry and pigs, due to the low fibre utilization efficiency of these animals. Higher values of the NFE observed among the orange by-products showed that they were potentially high in energy content.

The significant increase in the average daily feed intake observed among rabbits fed WOM was an indication that the feed was palatable, with the rabbits in this group showing more preference. (17) suggested that the quantity of feed intake in rabbits is dependent to a large extent on the palatability of the feed, its consistency, and

the crude fibre content of the feed. (18) indicated that the palatability of feed has an increasing effect on feed intake, nutrient availability, and subsequently, appetite, thereby increasing feed intake. (19) gave an average feed intake range of 39.83–49.03 g, which was similar to the findings of this experiment.

**Table 2.** Proximate compositions of orange waste meal and wheat offal (% Dry matter)

Compositions (%)	OPM	OMM	OEM	WOWM	Wheat offal
Crude protein	3.50±0.03 <sup>d</sup>	5.25±0.01 <sup>c</sup>	6.56±0.05 <sup>b</sup>	6.00±0.04 <sup>b</sup>	15.50±0.16 <sup>a</sup>
Crude fibre	15.00±0.04 <sup>a</sup>	15.50±0.06 <sup>a</sup>	10.70±0.03 <sup>c</sup>	13.10±0.05 <sup>b</sup>	8.70±0.03 <sup>d</sup>
Ether extract	2.25±0.03 <sup>b</sup>	0.75±0.05 <sup>c</sup>	0.75±0.01 <sup>c</sup>	0.74±0.06 <sup>c</sup>	3.50±0.06 <sup>a</sup>
Ash	3.00±0.02 <sup>b</sup>	1.00±0.00 <sup>d</sup>	3.00±0.02 <sup>b</sup>	2.30±0.06 <sup>c</sup>	6.00±0.01 <sup>a</sup>
Nitrogen free extract	77.5±0.20 <sup>a</sup>	73.99±0.06 <sup>b</sup>	74.99±0.07 <sup>b</sup>	77.96±0.05 <sup>a</sup>	66.30±0.07 <sup>c</sup>
Dry matter	96.25±0.04	96.49±0.04	96.00±0.04	96.40±0.05	95.41±0.07

Values are means of triplicate determination.

<sup>abc</sup> Means in the same row with unlike superscripts differ ( $P < 0.05$ ).

**OPM** = Orange peel meal

**OMM** = Orange mesocarp meal

**OEM** = Orange endocarp meal

**WOWM** = whole orange waste meal

Growth performance of rabbits fed diets containing orange by-products as a fibre source

The growth performance of rabbits fed diets containing orange waste meal as fibre source is presented in Table 3. Rabbits fed the whole orange waste meal (WOWM) recorded a significantly ( $P < 0.05$ ) higher mean daily feed intake of 58.68 g, while rabbits fed the control diet recorded the lowest mean feed intake of 40.47g. The mean daily weight of rabbits fed diets containing orange waste meal increased (12.89g-13.99g) significantly ( $P < 0.05$ ) relative to those fed the control diet containing wheat offal as the main fibre source. The feed conversion ratio (FCR) differs significantly ( $P < 0.05$ ) among various treatment groups, with the rabbits on OMM meal recording a superior FCR (3.62) compared with those fed control (4.39) diets containing OEM (4.08) and WOWM (4.19). The FCR values for

rabbits on OMM and WOWM diets were, however, superior to those of rabbits fed the control diet.

The low daily weight gain by rabbits fed the control diet (9.21g) could be linked to the decrease in feed intake, which consequently prevented the intake of other nutrients required for growth (17). (20) and Aderinola *et al.* (21) reported an average daily body weight range of 5.23 g and 13.23 g, 15.31 g and 18.82 g, and 12.00 g and 18.80 g for growing rabbits fed ripe plantain peel, *Centrosema pubescens*, and cocoa pod husk-based diets, respectively. (14) also reported an average daily weight gain range of 5.90–11.05 for rabbits fed diets containing brewers dried grain, maize serviette, and rice bran, respectively. (22) gave 11.39–18.95 g as the average daily weight gain of rabbits fed

raw and differently processed Kapok (*Ceiba pentandra*) seed meal. (23) gave a range of 12.47–13.52 g as the mean daily weight gain for rabbits fed molasses improved sorghum brewers dried grain. The reports of these authors agrees with the findings of this experiment.

Improved FCR values (3.62-4.19) for rabbits fed orange pulp meal diets show that diets were efficiently utilized and that the feeds were effectively converted to meat. The values obtained in this experiment were similar to the range (3.92–4.39) indicated by (22) for rabbits fed diets containing differently processed Kapok (*Ceiba pentandra*) seed meal but superior to the range (5.40–6.73) demonstrated by (14) for rabbits fed diets containing brewers dried grain, maize serviette, and rice bran, respectively. The FCR value obtained in this study was also superior to the range (4.59–0.75) given by (3) for rabbits fed diets containing pawpaw seed meal.

This observation could be attributed to the use of orange mesocarp and endocarp combinations in the diet, which may have

made the feed palatable and more acceptable to the animals.

### Carcass and internal organ characteristics

The result of the carcass and internal organ characteristics in Table 4 showed that replacing wheat offal with orange pulp meal in the rabbits' ration had no significant influence ( $P > 0.05$ ) on the dressing percentage, primal cut, or the internal organs of rabbits. The non-significant effect of orange waste meal diets on rabbits' carcass and internal organs implies that the waste meal did not contain any substances detrimental to the animal. The reduction in the cost per kilogram of meat produced indicated substituting orange waste meal for wheat offal in the rabbit ration could reduce the cost of producing rabbits, thereby making its product available to end users at an affordable rate.

**Table 3.** Growth performance of rabbits fed diets containing orange by-products as fibre source

Parameters	Fibre sources				±SEM
	Wheat offal	OMM	OEM	WOWM	
Initial weight/rabbit(g)	686.67	681.66	676.67	676.67	±1.02
Final weight/rabbit(g)	1460.79	1764.46	1760.30	1851.83	±7.58
Weight gain/rabbit(g)	774.12 <sup>b</sup>	1082.76 <sup>a</sup>	1083.63 <sup>a</sup>	1175.16 <sup>a</sup>	±7.64
Mean daily weight gain/rabbit(g)	9.21 <sup>b</sup>	12.89 <sup>a</sup>	12.38 <sup>a</sup>	13.99 <sup>a</sup>	±0.83
Mean daily feed intake /rabbit(g)	40.47 <sup>c</sup>	46.70 <sup>b</sup>	50.59 <sup>b</sup>	58.68 <sup>a</sup>	±1.60
Feed conversion ratio (FCR)	4.39 <sup>a</sup>	3.62 <sup>b</sup>	4.08 <sup>b</sup>	4.19 <sup>a</sup>	±0.29

<sup>ab</sup> Means with different superscripts on the same row are significantly different ( $P < 0.05$ ).

SEM: standard error of mean

OMM = Orange mesocarp meal

OEM = Orange endocarp meal

WOWM = whole orange waste meal

**Table 4.** Carcass and internal organs characteristics of rabbits fed diets with different fibre

Parameters	Different fibre sources				±SEM
	Wheat offal	OMM	OEM	WOWM	
Live weight	1175.00	1403.33	1280.00	1460.60	5.26
Carcass weight	942.44	1222.55	1060.11	1211.94	5.38
Dressing percentage	80.20	87.14	82.82	82.98	0.79
<b>Prime cuts (% live weight)</b>					
Head	11.52	11.65	10.90	10.67	0.32
Thigh	23.91	24.13	24.26	26.71	0.53
Loin	21.75	22.59	19.55	18.67	0.63
Shoulder	18.91	20.83	21.82	18.25	0.59
<b>Internal organs (% live weight)</b>					
Heart	1.12	1.03	1.01	1.03	0.45
Liver	2.06	2.35	2.01	1.95	0.19
Kidney	0.77	0.68	0.76	0.67	0.11

Means with different superscript on the same row are significantly different ( $P < 0.05$ ).

±SEM: Standard error of mean

OMM = Orange mesocarp meal

OEM = Orange endocarp meal

WOWM = whole orange waste meal

#### **Economics of feeding different fibre sources to growing rabbits**

The economics of feeding the orange waste meal to rabbits are presented in Table 5. The cost of producing a kilogram of feed was significantly ( $P < 0.05$ ) reduced from N 178.15 for the wheat offal diet to N 171.65 each for diets containing endocarp, mesocarp, and whole orange waste meal. The costs of feed consumed were significantly ( $P < 0.05$ ) increased from N 605.62 for rabbits fed wheat offal diet to N 672.86, N 720.51, and N 846.23, respectively for rabbits on OMM, OEM and WOWM diets, respectively. Rabbits fed diet containing wheat offal recorded a significantly ( $P < 0.05$ ) higher cost of feed per kilogram weight gain (782.33), while rabbits on WOWM diet recorded the lowest cost of feed per kilogram weight gain with the value corresponding to N 456.96. The result revealed that it was relatively cheaper to include the orange by-

products in the diet of rabbits than including the most expensive wheat offal.

#### **Linear body measurements of rabbits fed diets containing orange waste meal as a fibre source**

The results of the linear body measurements of rabbits fed orange waste meal are presented in Table 6. The result revealed that the head length (HL), body length (BL), heart girth (HG), hind limb length (HLL), and forelimb length (FLL) differed significantly ( $P < 0.05$ ) among the treatment groups, while the ear and tail lengths showed no statistical difference ( $P > 0.05$ ). The values for the body length were 25.46 cm for the rabbits on the OEM diet, 25.89 cm for the rabbits on wheat offal meal, 27.47 cm for the rabbits on the OEM diet, and 28.92 cm for those fed the WOWM diet. The values for the head length followed a similar trend as those of the body length

across the treatment groups. However, the highest ( $P < 0.05$ ) heart girth (HG) length was observed in rabbits fed an OEM diet. Interestingly, the body length, hind limb length, and forelimb length of rabbits fed the WOWM diet differed significantly ( $P < 0.05$ ) among the treatment groups.

**Table 5.** Economics of feeding different fibre sources to growing rabbits

Parameters	Different fibre sources				±SEM
	Wheat offal	OMM	OEM	WOWM	
Cost/kg of feed formulated (₦)	178.15 <sup>a</sup>	171.65 <sup>b</sup>	171.65 <sup>b</sup>	171.65 <sup>b</sup>	±0.84
Cost/kg of feed consumed (₦)	605.62 <sup>d</sup>	672.86 <sup>c</sup>	720.51 <sup>b</sup>	846.23 <sup>a</sup>	±4.69
Cost/kg of feed as weight gain (₦)	782.33 <sup>a</sup>	621.43 <sup>b</sup>	673.21 <sup>b</sup>	456.96 <sup>c</sup>	±5.41

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

±SEM: Standard error of mean

OMM = Orange mesocarp meal

OEM = Orange endocarp meal

WOWM = whole orange waste meal

**Table 6.** Linear body measurement of rabbits fed diets containing orange waste meal as fibre source.

Parameters	Different fibre sources				±SEM
	Wheat offal	OMM	OEM	WOWM	
Head length	10.61 <sup>a</sup>	10.74 <sup>b</sup>	9.73 <sup>c</sup>	11.70 <sup>a</sup>	±0.39
Body length	25.89 <sup>c</sup>	27.34 <sup>b</sup>	25.46 <sup>d</sup>	28.92 <sup>a</sup>	±0.58
Hearth girth	19.60 <sup>cd</sup>	22.66 <sup>ab</sup>	22.10 <sup>b</sup>	19.21 <sup>d</sup>	±0.61
Hind limb	22.13 <sup>bc</sup>	22.70 <sup>b</sup>	21.34 <sup>c</sup>	23.95 <sup>a</sup>	±0.49
Fore limb	13.34 <sup>c</sup>	13.62 <sup>bc</sup>	14.73 <sup>b</sup>	16.61 <sup>a</sup>	±0.57
Ear length	8.45	9.52	8.42	9.54 <sup>c</sup>	±0.37
Tail length	6.56	8.14	7.94	8.48 <sup>c</sup>	±0.43

abc Means with different superscripts on the same row are significantly different ( $P < 0.05$ ).

±SEM: Standard error of mean

OMM = Orange mesocarp meal

OEM = Orange endocarp meal

WOWM = whole orange waste meal

### Conclusion and Applications

The result of this study revealed that

- 1) Wheat offal was superior to orange waste meal (mesocarp, endocarp, or whole) in crude protein, crude fibre and ash contents.
- 2) Including orange waste meal in diet as fibre source improved the mean weight gain and feed conversion ratio of rabbits relative to wheat offal.
- 3) Dietary inclusion of orange waste meal reduced the cost of feed production and cost/kg of feed as weight gain of rabbits compared wheat offal.

- 4) Dietary application of orange waste meal had no negative influence on the carcass, internal organs and the linear body measurements of rabbits.
- 5) It was recommended that whole orange waste meal (WOWM) should be used as a fibre source in feed formulation for the growing rabbits in place of wheat offal, and orange mesocarp and endocarp meals.

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