East African Scholars Journal of Agriculture and Life Sciences
Abbreviated Key Title: East African Scholars J Agri Life Sci
ISSN 2617-4472 (Print) | ISSN 2617-7277 (Online)
Published By East African Scholars Publisher, Kenya

OPEN ACCESS

Volume-3 | Issue-10 | October-2020 |

DOI:10.36349/easjals.2020.v03i10.001

Research Article

Utilisation of Biodegraded Sweet Orange (*Citrus sinensis*) Fruit Peel as a Replacement for Maize in Grower Rabbit Diet

Oluwabiyi Oluremi[1*], Janet Shiddi[2], Motselisi Mahlehla[1] and Adesina Adenkola[3]

[1]Department of Animal Science, National University of Lesotho, Roma, Lesotho
[2]Department of Animal Nutrition, [3]Department of Veterinary Biochemistry, Physiology and Pharmacology, Federal University of Agriculture, Makurdi, Nigeria

Article History
Received: 04.02.2020
Accepted: 19.03.2020
Published: 10.10.2020

Journal homepage:
http://www.easpublisher.com/easjals/

Quick Response Code

Abstract: A seventh-day feeding trial was done to assess the effect of Sweet orange (*Citrus sinensis*) fruit peel (SOP) biodegraded with bovine rumen content (RC) on the growth response of 5-week old New Zealand white rabbit. Fresh SOP divided into 4 equal portions SOP_0, SOP_1, SOP_2 and SOP_3, were mixed with RC in ratios 1:0, 1:01, 1:02 and 1:0.3 w/w, respectively. Each mixture was tied in a polythene sac, fermented for 48 h, sun-dried to 10% moisture and the dried RC removed. Milled SOP_0, SOP_1, SOP_2 and SOP_3 replaced 10% maize in control diet T_1 to produce SOP based-diets T_2, T_3, T_4 and T_5, respectively. Thirty rabbits were grouped into 5 of six each with similar weight, and randomly assigned to one each of five diets. Rabbits were fed and served water *ad-libitum*. Growth performance, carcass yield and nutrient digestibility were determined. Diets had significant effect ($p<0.05$) on protein intake, protein conversion ratio but not on body weight, weight gain, feed intake, feed conversion, water consumption, feed:water ratio. Dressing percentage and carcass cuts did not vary significantly ($p>0.05$) but percent neck weight, liver weight and small intestine length varied significantly ($p<0.05$). Coefficient digestibility of crude protein, fibre and fat differed significantly ($p<0.05$). SOP biodegraded with bovine rumen content in ratio 1:0 to 1:0.3 can replace 10% dietary maize without adverse effect on growth response of rabbit.

Keywords: Sweet orange peel, biodegraded, rabbit, growth response.

INTRODUCTION

Proteinaceous foods especially animal protein in developing countries like Nigeria is inadequate to meet human demands [1]. This is because of unrestrained ever increasing population growth, inadequate supply of feed ingredients due to use of obsolete agricultural technology practices by majority of farmers, the attendant high cost of grains, disease, inclement weather now complicated by climate change issues. Conventional feeds like maize, soyabean meal, groundnut cake, fish meal are in high demand for human consumption and industrial use and this being part reasons for their shortage, high cost, and, prohibitive cost of animal products. In order to mitigate the problem of food insecurity in Nigeria and indeed in developing countries, improvement in the quality and increase in the supply of animal protein sources is therefore critical. A possible practical solution to this problem will involve finding suitable alternative feed ingredients which are locally available and abundant, not consumed by man and can serve as cheap replacements for the conventional grains. This will ensure a sustainable flow of feedstuffs to support the livestock industry for the supply of the much needed animal protein. On-going research efforts in this direction have highlighted the importance of some agricultural wastes, one of which is sweet orange peel [2]. The cultivation of citrus fruits (which includes grapefruit, lemon and lime, oranges, and tangerine among other fruits) has been a preferred economic activity in some parts of the world because it is not labor intensive. Citrus thrives in any season, especially during spring, and production is common in the Northern Hemisphere, particularly in countries around the Mediterranean. There are about 140 major citrus producing countries according to the UNCTAD and, it has been reported that Nigeria is the 9th major citrus fruit producing country globally, with about 3.4 Million metric tonnes of citrus fruits produced annually [3]. Most citrus production is accounted for by oranges, but significant quantities of grape fruits, lemons and limes are also grown. In Nigeria, orange is grown in any part of the country as the climatic conditions have proven to be suitable for its growth, and orange is widely rated as the most planted fruit in Nigeria [4]. Of the three major varieties, sweet orange is the most popular. Studies evaluating the nutritive value of sweet orange peel and utilization of its meal by poultry, rabbits and goats have brought to the fore the potential of sweet orange peel as feed resource of promise to replace maize in farm animal diets. However, one of the problems encountered in the utilization of sweet orange peel is the presence of anti-nutritional factors namely; limonene, saponin, tannin, oxalate, phytate which are able to impair nutrient utilization particularly by the monogastric animals [5]. Another difficulty is its fairly high crude fibre content which has been reported to be in the range of 12.9% to 14.6% [6]. Rabbit, a non-ruminant herbivore possesses an inherent tract adaptation to tolerate moderately fibrous diets than poultry and swine. The presence of caecal microbiota in rabbit may also be an advantage in overcoming the negative effect of anti-nutritional factors present in most unconventional feed on nutrient utilization [7]. Furthermore, advantage can be taking of rabbit because of its small body size, short gestation period, high reproductive potentials, rapid growth rate, prolific nature and efficiency in feed conversion [8], and, also that the animal is experiencing increasing population and acceptability because of its white meat and low fat content which make it an animal protein source of choice on health grounds.

A number of processing techniques such as sun drying [9], toasting [10], soaking in water [11], cooking [12], roasting [13] and fermentation [14] have been reported to improve the nutritive value of many of the identified alternative feed resources with varied effects on the performance of farm animals. The objective of this study was therefore to evaluate the feed value of biodegraded sweet orange fruit peel obtained from bovine rumen content treatment, as a replacement for maize in grower rabbit feeding.

EXPERIMENTAL SECTION

The study was conducted at the Federal University of Agriculture Makurdi, Nigeria, Livestock Teaching and Research Farm. Makurdi is located on latitude 7°43′N and longitude 8°3′E [15]. The area is warm with a minimum temperature range of 24.20 ± 1.40°C and maximum temperature range of 36.33 ± 3.70°C while, rainfall is between 508 and 1016mm, and relative humidity is between 39.50 ± 2.20 and 64.00 ± 4.8% [16].

Sweet orange (*Citrus sinensis*) fruit peels (SOP) were collected from orange retailers who sold peeled orange fruits for direct human consumption. Collected sweet orange peels were divided into four equal portions coded SOP_0, SOP_1, SOP_2, and SOP_3 and were mixed with ruminal content (RC) of cattle in a ratio of 1:0, 1:0.1, 1:0.2, 1:0.3 w/w, respectively. Each of the SOP-RC mixture was put in a polythene sac with the open end tied, and the mixture left to ferment for 48 hours. Thereafter, the content of each sac was sun-dried on a concrete platform until the sweet orange peels attained about 10% moisture. Dried rumen content stuff was separated from SOP_0, SOP_1, SOP_2, and SOP_3 by hand picking. Samples of the sun-dried sweet orange peels were milled and samples analysed using standard methods [17] for their proximate constituents (Table 1), while the remaining portions of the biodegraded SOP_0, SOP_1, SOP_2, and SOP_3 were stored and milled when needed for diet compounding. Five experimental diets were compounded which consisted of the control diet (T_1), and sweet orange peel based diets T_2, T_3, T_4, and T_5 in which SOP_0, SOP_1, SOP_2, and SOP_3 replaced dietary maize in the control diet at 10% (Table 2).

Thirty (30) New Zealand rabbits with body weight range of 616 g to 621 g at 5 weeks old were used for the experiment. They were grouped into five, each consisting of six rabbits each. Each rabbit served as a replicate and housed singly in marked cages of dimension 40cm x 30cm x 30 cm. The groups were randomly assigned to five dietary treatments. They were fed *ad libitum* and provided adequate drinking water between 07.00 and 09.00 hours daily for the duration of 70 days the feeding trial lasted. The experimental arrangement was a completely randomized design.

The Experiment data collected were

a). Growth performance

Growth performance was observed during which initial body weight, final body weight, feed intake, water consumption, and mortality were determined. Body weight gain ((BWG), feed conversion ratio, protein intake and protein efficiency ratio (PER) were calculated. Body weight gain was determined by subtracting rabbit weight at the start of a week from its weight at the end of week, and finding the daily average for the duration of the feeding trial. Feed intake was obtained by subtracting the unconsumed feed at the end of a week from the feed supplied at the start of same week and finding the daily average for the duration of the feeding trial. Feed conversion ratio (FCR) was determined as the ratio of feed intake to body weight gain ($\frac{\text{Feed intake}}{\text{Body weight gain}}$). Water intake was determined by subtracting the unconsumed water from the quantity of water supplied 24 hourly and calculating the average consumption for the duration of the feeding trial. Protein intake was calculated as feed intake x % crude protein in diet and protein efficiency ratio (PER) = $\frac{\text{Body weight gain}}{\text{Protein intake}}$

b). Carcass yield

Carcass yield evaluation was carried out on the seventieth day when the feeding trial was terminated. Ten (10) rabbits at the rate of two rabbits from each treatment were selected and deprived of feed for 18 hours. The fasted live weight of each rabbit was taken. Thereafter, they were bled by cutting the jugular vein and the carotid arteries. Each bled rabbit was hung head down to allow blood to drain under gravity, and bled weight taken. The rabbits were singed and weighed. Thereafter, they were eviscerated and weighed and, the dressing percentage calculated as: Dressing percent = $\frac{\text{Dressed weight}}{\text{Fasted live weight}} \times 100$

Carcass cuts namely head, neck, leg, thigh, shoulder, ribs, loin, visceral organs namely liver, heart, lungs, kidney, spleen, gall bladder, pancrease and, the gastrointestinal tract and its sections namely small intestine, large intestine, caecum, stomach, oesophagus were weighed with a digital balance while. The length of the gastrointestinal tract and its components were taken with a meter rule [18].

c). Digestibility:

Digestibility trial was carried out at the end of 10^{th} week of the experiment. A pre-determined 150 g of experimental diet was given to each rabbit daily for five days and faecal pellets were collected during this period by placing nylon net under each rabbit cage. The wet weight of the faeces collected from each rabbit was taken, oven-dried to 10% moisture and dried weight taken. The total faecal collections from each replicate was pooled, milled and homogenous sample from each replicate was taken for proximate analysis [17]. The apparent digestibility of nutrients was calculated as:

Nutrient digestibility = [Nutrient intake – Nutrient in faeces / Nutrient intake] x 100

Statistical Analysis

The data collected in the feeding trial were subjected to the analysis of variance [19] and where there was significant difference ($p<0.05$), means were separated using Duncan multiple range test [20].

RESULTS AND DISCUSSION

The effect of the experimental diets on the growth response of rabbits is presented in Table 3. The diets did not affect final body weight, feed intake, body weight gain, feed conversion ratio, water consumption and feed/water ratio significantly ($p>0.05$) across the treatments and also, the values obtained for all these growth indices did not show a specific order of variation. The diets had significant ($p<0.05$) effect on the protein intake and protein conversion ratio of the rabbits. The growth response obtained suggests that the feed value of sweet orange peel has been enhanced by its biodegradation as observed [21], despite the presence of tannin, saponin, phytate, oxalate, flavonoid and limonene in sweet orange peel [14], some of which can depress the growth of farm animals because of interference with absorption of nutrients. This can be seen in the comparable feed intake (48.65 – 53.28 g), feed conversion ratio (4.21 – 4.57) and final body weight (1601.00 – 1666.67 g) of the rabbits in both the maize and sweet orange peel meal based diets. The final body weight which is often the yardstick for the sale of live farm animal was lower than a range of 1691.00 to 1928.00 g for rabbit reported when bovine rumen filtrate was used to process sweet orange peel [22].

The result of rabbit carcass yield indicated that with the exception of the neck cut, the dressing percent, forelimb, hind limb, loin, rib, rack and head of rabbits were not affected significantly ($p>0.05$) by the diet treatments across the treatments (Table 4). The Non-significant difference values obtained for carcass cuts of the rabbits across the groups therefore implied that the incorporation of biodegraded sweet orange peel into rabbit diet as a replacement for maize at 10% did not interfere with the utilisation and conversion of feed nutrients into meat and other associated meat tissue constituents. The significant ($p<0.05$) variation observed in the neck weight (2.61 – 3.62 % LW) did not follow any sequence and hence, it is difficult to attribute the difference to the experimental diets. Similarly, the percentage live weight (% LW) of the other carcass yield indices, with the exception of the dressing percent and the rack did not have a particular pattern of variation and cannot be linked to treatment effect. The dressing percentage of 49.46 – 56.27% in this study which is the proportion of live weight obtained as carcass was within the normal range of 48.0 – 75% for mammals depending on the species, age, weight, diet, gut fill and sex [23].

The dietary treatments effect on the visceral organs and fat affected the liver weight relative to the live weight of rabbit significantly ($p<0.05$), whereas the kidney, gall bladder, heart, lung, pancrease and spleen, and the visceral fat did not differ significantly ($p>0.05$) across the treatments (Table 5). The liver weight obtained in this study varied from 2.13% to 3.06% and smaller than 3.30% to 3.80% earlier reported [24]. Furthermore, it had no definite order of variation across the treatments. High liver weight has been shown to be an indication of higher metabolic rate of the liver to reduce or eliminate toxins in the body system [25]. This result is a probable indication that the rabbits receiving the sweet orange based diets were not exposed to loads of anti-nutrients when used at 10% level replacement for dietary maize. The non significant ($p>0.05$) difference in respect of kidney, heart, gall bladder, lung, spleen and pancrease suggests that the biodegraded sweet orange peels did not cause a compromise in the performance of the physiological functions of these organs in the rabbits. The depressed quantity of the visceral fat in the rabbits fed the biodegraded sweet orange peel meal diets was readily observed, even though not significantly ($p>0.05$) different from the visceral fat content found in rabbits fed the maize based diet treatment (Control). This is consistent with earlier research finding in broiler chicken feeding trials [26], which evaluated biodegraded sweet orange peel as feed resource.

The various gut dimensions showed no significant ($p>0.05$) difference with the exception of the stomach length ($p<0.05$) across the dietary treatments. Irregular pattern characterized the values obtained for the length of the GIT, small and large intestines, caecum and oesophagus, including the stomach. This shows that it is safe to use biodegraded sweet orange peel as a substitute for maize at 10% level in the diet of grower rabbit.

The coefficient of digestibility of nutrient by grower rabbit is presented in Table 6. There was significant ($p<0.05$) variation in crude protein, crude fibre and ether extract digestibility across the dietary treatments while, there was no significant ($p>0.05$) difference in the digestibility of nitrogen free extract and dry matter. Two important factors regulating feed quality are crude protein and fibre. The coefficient of CP digestibility in the maize-based diet group was higher (86.35%) compared to the biodegraded sweet orange-based diet groups (76.35 – 79.93%). This may be the consequence of binding with protein by some anti-nutrients like saponin and tannin present in the sweet orange peel [14], thereby decreasing the amount of protein available for protease digestive activity. The ability of tannin to bind dietary protein in rabbit has also been reported [27]. The crude fibre digestibility in this study is low ranging from 32.99 to 52.49% in spite of the use of rabbit a non-ruminant herbivore. This may have been due to the fact that grower rabbits were used with relatively less developed caecum, to handle the microbial digestion of the dietary fibre fractions, consisting mainly high proportions of NDF (61.33%) and ADF (39.71%) as reported by [6].

The study has shown that growth response of grower rabbits fed diets containing biodegraded sweet orange peel meal based-diets was comparable to rabbits fed the maize based control diet. Thus, sweet orange fruit peel (SOP) biodegraded with bovine rumen content (RC) in the ratio of 1:0 to 1:0.3 can replace 10% maize in grower rabbit diet without adverse effect.

Table-1: Proximate Composition and Energy Content of Biodegraded Sweet Orange Peel

Treated sweet orange peel	**DM (%)**	**Crude protein (%)**	**Crude fibre (%)**	**Ether extract (%)**	**Ash (%)**	**NFE (%)**	**Metabolizable Energy (kcal/kg)**
SOP_1	86.60	8.15	13.88	3.22	7.67	67.06	2913.92
SOP_2	87.05	7.71	14.73	2.23	6.64	68.67	2871.73
SOP_3	83.07	8.42	15.82	2.50	8.14	65.11	2795.28
SOP_3	81.43	9.26	15.29	3.41	8.94	63.08	2829.57

SOP_1 = 1SOP: 0 RC (10kg of sweet orange peel without rumen content)
SOP_2 = 1SOP: 0.1 RC (10kg of sweet orange peel to 1kg of rumen content)
SOP_3 = 1SOP: 0.2 RC (10kg of sweet orange peel to 2kg of rumen content)
SOP_4 = ISOP: 0.3 RC (10kg of sweet orange peel to 3kg of rumen content)

Table-2: Gross Composition of the Experimental Diets

Ingredients (kg)	**Experimental diets**				
	$\mathbf{T_1}$	$\mathbf{T_2}$	$\mathbf{T_3}$	$\mathbf{T_4}$	$\mathbf{T_5}$
Maize	47.50	37.50	37.50	37.50	37.50
Sweet orange peel meal	0	10.00	10.00	10.00	10.00
Full-fat soybean	24.80	24.80	24.80	24.80	24.80
Brewers dried grain	6.50	6.50	6.50	6.50	6.50
Rice offal Bone meal	17.75 3.00	17.75 3.00	17.75 3.00	17.75 3.00	17.75 3.00
Premix*	0.25	0.25	0.25	0.25	0.25
Common salt	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Calculated Nutrients					
Crude protein	15.69	14.79	14.79	14.79	14.79
Crude fibre	10.09	9.89	9.89	9.89	9.89
Ether extract	7.39	6.99	6.99	6.99	6.99
Calcium	1.16	1.16	1.16	1.16	1.16
Phosphorus	0.72	0.71	0.71	0.71	0.71
Energy (Kcal ME/kg)	2742.38	2680.29	2719.87	2672.51	2752.02

*Vitamin/Mineral Premix : Vit A - 1,200,000mg, Vit D_3 – 300,000mg, Vit E – 3,000mg, Vit K_3-250mg, Folic acid – 100mg, Niacin - 4,000mg, Calpan - 1,000mg, Vit B_3 - 500mg, Vit - B_{12} - 2mg, Vi - B_1-200mg, B_6 - 350mg, Biotin 8mg, Antioxidant12,500mg, Cobalt-25mg, Selenium-25mg, Iodine-120mg, Iron-4,000mg, Manganese 4,000mg , Copper 600mg, Zinc-6,000mg, Choline chloride 20,000mg.
ME = metabolisable energy = [37 x %CP] + [81.8 x %EE] + [35.5 x %NFE] ……………….. (Pauzenga, 1985)
T_1 = Control diet
T_2 = Diet containing 10% SOP_1 as replacement for maize
T_3 = Diet containing 10% SOP_2 as replacement for maize
T_4 = Diet containing 10% SOP_3 as replacement for maize
T_5 = Diet containing 10% SOP_4 as replacement for maize

Table-3: Effect of Experimental Diets on Performance of Grower Rabbits

Parameters	Experimental Diets					SEM	LOS
	T_1	T_2	T_3	T_4	T_5		
Initial body weight (g)	617.50	616.67	616.47	620.80	621.67		
Final body weight (g)	1665.00	1650.00	1637.50	1666.67	1601.67	58.0	ns
Daily feed Intake (g)	53.05	48.65	50.41	53.28	48.94	2.14	ns
Daily body weight gain (g)	12.52	11.21	12.15	12.35	11.67	0.68	ns
Feed conversion ratio	4.31	4.41	4.21	4.57	4.34	0.28	ns
Protein intake	14.44^{a}	8.40^{b}	11.17^{ab}	11.77^{ab}	11.27^{ab}	044	*
Protein conversion ratio	0.86^{b}	1.33^{a}	1.09^{ab}	1.05^{ab}	1.04^{ab}	0.06	*
Water consumption (ml)	169.30	165.49	222.59	192.08	179.78	25.99	ns
Feed/water ratio (g/ml)	3.85	3.13	3.85	3.13	3.45	0.54	ns

^{ab} Means with different superscripts in the same row are significantly different (P<0.05).
^{ns} Not significantly different (P>0.05), SEM = Standard error of mean, LOS = level of significance
T_1= Control diet
T_2= Diet containing 10% of SOP_1 as replacement for maize
T_3= Diet containing 10% of SOP_2 as replacement for maize
T_4= Diet containing 10% of SOP_3 as replacement for maize
T_5 = Diet containing 10% of SOP_4 as replacement for maize

Table-4: Effect of Experimental Diets on Carcass Yield of Grower Rabbits

Parameter	Experimental diets					SEM	LOS
	T_1	T_2	T_3	T_4	T_5		
Fasted live weight	1480.00	1600.00	1583.33	1583.33	1550.00	0.80.56	Ns
Dressed weight	900.00	848.33	825.00	801.66	766.66	3.46	Ns
Dressing percent	56.27	53.50	51.76	50.56	49.46	2.62	Ns
Hind limbs (% LW)	19.70	19.36	19.66	18.13	19.25	1.35	Ns
Fore limbs (% LW)	11.21	11.02	9.14	10.14	11.18	1.61	Ns
Loin (% LW)	13.53	13.34	11.81	12.83	12.15	2.26	Ns
Rib (% LW)	10.50	8.36	8.50	9.58	8.28	2.04	Ns
Rack (% LW)	5.82	5.55	5.22	4.93	4.84	0.57	Ns
Head (% LW)	8.00	6.58	7.21	7.83	7.95	1.54	ns
Neck (% LW)	3.02^{ab}	2.61^{b}	2.82^{ab}	3.62^{a}	3.12^{ab}	0.61	*

%LW = percent live weight.
^{a,b} Means with different superscripts in the same row are significantly different (P<0.05).
^{ns} Not significantly different (P>0.05), SEM = Standard error of mean, LOS = level of significance.
T_1= Control diet
T_2= Diet containing 10% of SOP_1 as replacement for maize
T_3= Diet containing 10% of SOP_2 as replace for maize
T_4= Diet containing 10% of SOP_3 as replacement for maize
T_5 = Diet containing 10% of SOP_4 as replacement for maize

Table-5: Effect of Experimental Diets on Visceral Organs and Visceral Fat of Grower Rabbits

Visceral parts	Experimental diets					SEM	LOS
	T_1	T_2	T_3	T_4	T_5		
Liver (% LW)	2.29^{ab}	2.13^{b}	3.06^{a}	2.31^{ab}	2.50^{ab}	0.03	*
Kidney (% LW)	0.28	0.31	0.37	0.31	0.37	0.07	ns
Heart (% LW)	0.09	0.11	0.16	0.16	0.16	0.33	ns
Gall bladder (% LW)	0.25	0.36	0.32	0.34	0.25	0.11	ns
Lungs (% LW)	0.36	0.34	0.32	0.30	0.27	0.086	ns
Spleen (% LW)	0.29	0.32	0.15	0.18	0.19	0.07	ns
Pancrease (%LW)	0.32	0.37	0.39	0.42	0.39	0.11	ns
Visceral Fat (% LW)	0.30	0.14	0.14	0.14	0.14	0.12	ns
Stomach length (% GIT)	2.35^{ab}	2.54^{a}	2.29^{ab}	1.83^{b}	2.22^{ab}	0.53	*
GIT length (cm)	100.00	99.99	99.73	100.63	100.00	4.85	ns
Small intestine length (%GIT)	60.53	61.48	63. 30	59.16	60.24	10.75	ns
Large intestine length (% GIT)	24.19	22.33	22.48	26.86	25.53	9.39	ns
Caecum length (% GIT)	10.43	10.53	8.96	9.56	9.48	2.29	ns
Oesophagus length (% GIT)	2.50	3.11	2.96	2.59	2.51	0.12	ns

%LW = per cent live weight.
^{a,b} Means with different superscripts in the same row are significantly different (P<0.05).
^{ns} Not significantly different (P>0.05), SEM = Standard error of mean, LOS = level of significance.
T_1= Control diet
T_2= Diet containing 10% of SOP1 as replacement for maize
T_3= Diet containing 10% of SOP2 as replacement for maize
T_4= Diet containing 10% of SOP3 as replacement for maize
T_5 = Diet containing 10% of SOP4 as replacement for maize

Table-6: Effect of Experimental diets on Coefficient of Digestibility of Nutrients by Rabbits

Nutrients	Experimental Diets					SEM	LOS
	T_1	T_2	T_3	T_4	T_5		
Dry matter	65.09	68.35	60.28	65.09	62.87	8.70	ns
Crude protein	86.35^{a}	77.71^{ab}	79.93^{ab}	78.75^{ab}	76.35^{ab}	5.17	*
Ether extract	87.01^{b}	92.63^{a}	91.62^{ab}	90.00^{ab}	87.73^{b}	1.81	*
Crude fibre	32.99^{b}	49.30^{ab}	48.64^{ab}	52.49^{a}	46.59^{ab}	6.49	*
Nitrogen free extract	70.58	75.89	66.71	73.24	72.80	4.68	ns

^{a,b} Means with different superscripts in the same row are significantly different (p<0.05).
^{ns} Not significantly different (P>0.05), SEM = Standard error of mean, LOS = level of significance.
T_1= Control diet
T_2= Diet containing 10% of SOP_1 as replacement for maize
T_3= Diet containing 10% of SOP_2 as replacement for maize
T_4= Diet containing 10% of SOP_3 as replacement for maize
T_5 = Diet containing 10% of SOP_4 as replacement for maize

REFERENCES

1. FAO. (2010). The State of Food Insecurity in the World. Food and Agricultural Organization.Rome, Italy.
2. Oluremi, O. I. A., Igyu, A.D., Abu, F.T. (2005). Response of growing rabbit to dietary replacement of maize with sweet orange rind, *Production Agriculture and Technology*, 1, 130-136.
3. Miaschi, J. (2017). *The World's Top Citrus Producing Countries*, World Atlas, https://www.worldatlas.com/articles/the-world's top-citrus-producing-countries.htm/.
4. Adegbija, D. (2018). *Problems and Prospects of commercial Orange farming in Nigeria*, https://infoguidenigeria.com/
5. Oluremi, O.I.A., Okafor, F. N., Adenkola, A. Y., Orayaga, K. T. (2010). Effect of fermentation of sweet orange (*Citrus sinensis*) fruit peel on its phytonutrients and the performance of broiler starter, *International Journal of Poultry Science*, 9, 546 – 549.
6. Oluremi, O.I.A., Andrew, I. A., Ngi, I. (2007). Evaluation of the Nutritive potential of some Citrus fruit varieties as feedingstuffs in Livestock production, *Pakistan Journal of Nutrition*, 8, 653-656.
7. Gidenne, T, Jehl, N., Segura, M., Michalet-Doreun, B. (2002). Microbial activity in the caecum of rabbit around weaning: Impact of a dietary fibre deficiency and of intake level, *Animal Feed Science and Technology*, 99, 107-118.
8. Bernerjee, G. C. (2009). *A Text Book of Animal Husbandry*, University of Oxford and IBH Publication Co, PVT. Ltd, New Delhi.
9. Ojebiyi, J.O., Farinu, G.O., Togun, V.A., Akinlade, J. A., Aderinola O. A., Olayeni, T. B., Moronfolu, O. O. (2007). Studies on growth and hematological attributes of weaner rabbits fed graded level of sun dried cassava peel blood meal mixture, *Proceedings of 32nd Annual Conference of Nigerian Society for Animal Production*, 213 – 216.
10. Tuleun, C. D., Dashe, W.A. (2010). Effect of dietary levels of toasted mucuna seed meal on the performance and egg quality parameter of laying Japanese Quails (*Coturnix coturnix japonica*), *Proceedings of 35th Annual Conference of Nigerian Society for Annual Production*, 344-346.
11. Orayaga, K.T., Oluremi, O. I. A., Kaankuka, F. G. (2010). Effect of water soaking of sweet orange (*Citrus sinensis*).fruit peel on its chemical composition and growth performance of broiler starter chicks, *Journal of Animal Production Resource Advances*, 6, 311 – 314.
12. Akinmutimi, A. H. (2007). Effect of cooking periods on the nutrient composition of velvet beans (*Mucuna puriens*), *Proceedings of 32nd Annual Conference of Nigerian Society for Animal Production*, 223 – 226.
13. Nwachukwu, C. B., lbitoye, O.E. (2008). Effects of roasting on protein quality of Bambara nut. *Proceedings of 33rd Annual Conference of Nigerian Society for Animal Production*, 319-230.
14. Oluremi, O.I.A., Ngi, A.J., Andrew, A.I. (2007). Phytonutrients in Citrus fruit peel meal and Nutritional implication for Livestock production. *Livestock Research for Rural Development*, 19, 1-5.
15. Tageo. (2009). A Database of Geographic Coordinates Information, www.tageo.com/index.htm.
16. TAC. (2009). *Makurdi Weather Element Records*, Nigeria Air Force Tactical Air Command akurdi, Nigeria.
17. A.O.A.C. (2000). *Association of Official Analytical Chemist*, William Byrd Press Inc. Richmond, Virgina, U.S.A.
18. Aduku, A. O., Olukosi, J. O. (1990). *Rabbit management in the tropics*, Living Book Series, G. U. Publication, Abuja, Nigeria, 1.
19. SPSS. (1999). *Statistical Package for Social Sciences*.
20. Duncan, D.B. (1955). Multiple range F test. *Biometric*, 11, 1-42.
21. Oluremi, O.I.A., Okafor, F.N., Adenkola A.Y., Orayaga, K.T. (2010). Effect of ensiling Sweet orange (*Citrus sinensis*) fruit peel on its Phytonutrients and the performance of broiler starter. *International Journal of Poultry Science*, 9, 546-549.

22. Oluremi, O.I.A., Ajih, E.E., Anthony, W. (2018). Evaluation of Rumen filtrate for Fermentation of Sweet orange (*Citrus sinensis*) peel in Rabbit feed, *Animal Veterinary Science*, 6, 1-5.
23. Whiteheart, R. (2012). *Yields and Dressing percentages*, Cornell Small Farms, Cornell College of Agriculture and Life Sciences. https://smallfarms.cornell.edu/2012/07.
24. Njidda, A.A., Isidahomen, C.E. (2011). Haematological parameters and carcass characteristics of weaner Rabbits fed Sesame seed meal (*Sesame indicum*) in semi-arid Region, Pakistan Veterinary Journals, 31, 35-39.
25. Ahamefule, K. U., Obua, B. E., Oguike, S.A. (2006). Blood Chemistry and haematology of weaner Rabbits fed sundried, ensiled and fermented cassava peel based diets, *Pakistan Journal of Nutrition*, 5, 248 – 253.
26. Nwobodo, E.A. (2017). *The Feed Value of Sweet Orange (Citrus sinensis) Peel Fermented with White Fulani Cattle Rumen content in Broiler Chicken Nutrition,* Ph.D thesis, Federal University of Agriculture, Makurdi, Nigeria.
27. Almamary, M., Molham, A., Abdulwali, A., Al-Obeide, A. (2001). *In-vivo* effect of dietary sorghum tannins on rabbit digestive enzyme and mineral absorption. *Nutritional Resources*, 21:1392 – 1401.