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Performance and blood profile of rabbits fed biodegraded -sweet orange (*Citrus sinensis*) peel based diets

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Target Audience: Rabbit farmers and feed millers

Abstract

The study assessed the performance of grower rabbits fed biodegraded sweet orange peel based diets. Thirty six (36) grower rabbits of mixed breed between 5 to 7 weeks old were randomly assigned to six (6) dietary treatments replicated 6 times in a completely randomized design. Biodegraded sweet orange peel was prepared by fermenting a mixture of sweet orange peel (SOP) and bovine rumen filtrate in ratios 10kg SOP: 2 litre filtrate (T_1), 10kg SOP: 4 litre filtrate (T_2), 10kg SOP: 6 litre filtrate (T_3), 10kg SOP: 8 litre filtrate (T_4), 10kg SOP: 10 litre filtrate (T_5) for 48hours and sun dried. Each of T_1, T_2, T_3, T_4, and $T_5$was used to replace 30% maize in the control diet to obtain five biodegraded SOP based diets. Parameters determined were feed intake, body weight gain, water consumption, feed conversion ratio (FCR), water: feed ratio, PCV, RBC, WBC, Hb, MCV, MCH, MCHC, serum total protein, albumin, globulin, cholesterol, creatinine, alanine aminotransferase and aspartate aminotransferase. Diets had significant effect ($p<0.05$) on daily water consumption of rabbits, but no significant effect ($p>0.05$) on final body weight, feed intake, body weight gain and FCR. No significant effect ($p>0.05$) was observed on any of PCV, RBC, WBC, Hb, MCV, MCH, MCHC but serum alanine aminotransferase and aspartate aminotransferase differed significantly ($p<0.05$). Rabbits can be fed with diet in which 30% maize is replaced, with biodegraded SOP obtained from 48 hours fermentation of SOP when mixed with bovine rumen filtrate, at ratio 1:1 to obtain a superior growth performance.

Keyword: Orange peel, Biodegradation, Rabbit, Performance, Blood profile

Description of Problem

Animal proteins consumed worldwide are desired mostly from meat of cattle, sheep, goat, pig and poultry. The supply of proteins from these livestock has been inadequate. This has led to a shift towards production of alternatives to those animals in attempt to achieve food security in a rapidly growing population and relative self-sufficiency in animal protein supply. The production of animal protein from small animals is seen as an alternative to mitigate the problems associated with protein inadequacy in developing countries like Nigeria. Rabbit offers a cheap and reliable alternative to the current protein crisis with its short generation interval (1, 2). In spite of its production and economic advantages over other livestock species, rabbit has not achieved its potential as a cheap source of animal protein in the tropics which has been attributed to inadequate and high cost of feed ingredients like grains and oil seeds brought about mainly by the stiff competition between man and non-ruminant animals (3). Nonetheless, nutritious animal feeds are essential for full development and

productivity of various farm animal species. Mitigating this problem partly lies in the search for cheap and readily available alternative feed materials. These alternative feed materials can be sourced from agro-allied by-products and farm residues especially in developing economies where there is a rise in these by-products and farm wastes due to increasing mechanization of crop farming. One of such wastes could emanate from citrus, a major fruit of sub-tropical regions (4). Nigeria is the ninth world major citrus producing country and produces about 3.4 million metric tonnes of citrus fruits annually from an estimated 3 million hectares of land (5). Most of the fruits are consumed directly due primarily to few and small capacity processing industries to convert the fruit to juice concentrate and canned drinks. Sweet orange (*Citrus sinensis*) peels contains 89.51% dry matter, 10.74% crude protein, 7.88% crude fibre, 12.60% ether extract and 3.98kcal/g energy (6). The presence of anti-nutritional factors has however, constrained the potentials of utilizing Sweet orange peel in livestock feeding. Fermentation has been shown to reduce saponin, limonene, tannin and flavonoid composition of sweet orange peels (7). Biodegradation of sweet orange peel may enhance its efficient utilization by rabbits giving the nature of its gastro intestinal tract. The aim of the study was to evaluate the effect of bovine rumen filtrate biodegradation of sweet orange and its use a replacement for maize in rabbit diet.

Materials and Methods

Experimental Site

The study was conducted at the Rabbitary unit of the Livestock Teaching and Research Farm, Federal University of Agriculture, Makurdi, Benue State, Nigeria. The area spans between latitude $7^0$43′N and longitude $8^0$3′E (8). The area is warm, having a characteristic tropical climate with a minimum temperature range of 24.20±1.4^{0}C and a maximum temperature range of 36.33±3.70^{0}C (9). Rainfall is between 508 and 1016 mm, with relative humidity of between 39.50±2.20 and 64.00±4.8%, and a mean wind speed of 2.47 knot/second North-East (9)

Source and Preparation of Test Ingredient

Sweet orange (*Citrus sinensis*) peels were collected from retailers in Makurdi metropolis. Fresh rumen content was collected from white Fulani cattle immediately after slaughter at the Wurukum Abattoir, in Makurdi. Rumen filtrate was prepared by mixing1 part rumen content with 1 part portable water (1:1). The mixture of rumen content and water was thereafter sieved to obtain rumen filtrate (RF). Sweet orange peels collected were divided into six parts and separately mixed with the rumen filtrate in the following ratios:10kg SOP : 2 litre RF (T_1), 10kg SOP: 4 litre RF (T_2), 10kg SOP: 6 litre RF (T_3), 10kg SOP: 8 litre RF (T_4), 10kg SOP: 10 litre RF (T_5). Each of T_1, T2, T_3, T_4, and $T_5$was put in separate polythene bags and allowed a 48 hours fermentation period, after which the SOP was removed and sundried to below 10% moisture. The sundried material was ground, analysed for proximate constituent (10) and used in formulating and compounding the experimental diets in the feeding trial.

Experimental diets

Six (6) experimental diets (Table 1) were prepared to meet the nutrients requirement of growing rabbits. One each of the processed SOP T_1, T2, T_3, T_4, and T_5 was used to replace 30% maize in the control diet (D) to obtain five (5) SOP based dietsT_1D, T_2D, T_3D, T_4D and T_5D.

Experimental Design and Management of Animals

Thirty six (36) weaner-rabbits of mixed breeds aged between 5 and 7 weeks obtained

from rabbit farmers in Makurdi metropolis were used in the experiment. The rabbits were housed individually in rabbit cages and were allowed seven days acclimatization period before the feeding trial which lasted for 84 days. The rabbits were randomly allotted to the six (6) experimental diets with each treatment made up of equal number of male and female animals in a completely randomized design (CRD).

Table 1: Gross composition of grower rabbits experimental diets (kg/100kg)

	Experimental Diets					
Ingredients	T_1D	T_2D	T_3D	T_4D	T_5D	T_6D
Maize	27.00	16.20	16.20	16.20	16.20	16.20
BSOP	0.00	10.80	10.80	10.80	10.80	10.80
Full fat soyabean	15.00	15.00	15.00	15.00	15.00	15.00
Brewers dried grain	25.00	25.00	25.00	25.00	25.00	25.00
Rice offal	30.00	30.00	30.00	30.00	30.00	30.00
Bone ash	2.50	2.50	2.50	2.50	2.50	2.50
Mineral/vitamin Premix*	0.25	0.25	0.25	0.25	0.25	0.25
Common salt	0.25	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00
CalculatedNutrient (%)						
Crude protein	16.20	15.82	15.84	15.86	15.84	15.88
Crude fibre	10.12	11.10	11.12	11.16	11.17	11.19
Ether extract	9.03	8.90	8.91	8.91	8.92	8.90
Ash	4.59	4.97	4.96	4.99	4.99	5.06
ME** (kcal/kg)	2774.60	2683.00	2673.40	2678.40	2678.70	2673.00

BSOP= Biodegraded sweet orange peel

*Premix added contained 24000iu vitamin A, 6000 vitamin B, 60 mg vitamin E, 5 mg vitamin k3, 2mg folic acid, 80 mg niacin, 20 mg Calpan, 4 mg vitamin BI, 10 mg vitamin B2, 7 mg vitamin B6, 0.04 mg vitamin B12, 0.16 mg biotin and 250 mg antioxidant, cobalt 0.5 mg, copper 16 mg, selenium 0.5 mg, iodine 24 mg, iron 80 mg, manganese 140 mg, zinc 120 mg and chloride 400 mg per kg diet.

**ME= Metabolizable energy = (37 x % CP) + (81.1 x % EE) + (35.5 x % NFE) ----- (13).

Feed and clean drinking water were supplied *ad libitum* throughout the 12 weeks feeding trial. Vitalyte (anti-stress) was orally administered through drinking water to mitigate effect of stress occasioned by movement and the new location. Oxy-tetracycline (LA) at the rate of 0.1ml was given for 3 days at alternate days. The floor of each cage was cleaned everyday and likewise the drinkers.

Data Collection and Analysis

Performance parameters collected directly were live body weight, taken at the beginning of the feeding trial and later at weekly intervals; feed intake, water consumption, body weight gain, feed conversion ratio (FCR), protein intake, protein efficiency ratio (PER) and water: feed ratio were calculated.

At the termination of the feeding trial, three (3) rabbits per treatment were selected for determination of haematological and serum-biochemical indices. Two (2) ml of blood sample was obtained at slaughter into heparinized tubes for haematological determination of red blood count (RBC), haemoglobin (Hb), packed cell volume (PCV), white blood count (WBC) using Mindray automatic blood analyzer. Mean corpuscular

volume (MCV), mean cell haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) were determined (11). Serum constituents were determined by collecting another two (2 ml) of blood at slaughter into non-heparinized test tubes. Serum constituents determined were serum total protein, globulin, albumin, cholesterol, creatinine, alanine aminotransferase (ALT), aspartate aminotransferase (AST) using sigma kits, and cholesterol determination followed the method of (12).

Results and Discussion

The result of rabbit body weight, feed intake, body weight gain, feed conversion ratio, water: feed ratio and mortality is presented in Table 2. The result showed that the use of biodegraded sweet orange peel as a replacement for maize had no significant effect ($p>0.05$) on all performance indices except daily water consumption. It was observed that rabbits in group T_5D had the highest average daily water consumption of 195.04ml and also the highest feed intake of 47.59g/day. The water consumption regime in the six diets was found to be lower than the range of 282.52 to 391.76ml that has been reported when rabbits were fed rumen filtrate biodegraded sweet orange peel (14). In the present feeding trial a minimum of 2.94 ml of water was required per gram of feed intake. Although, rabbits in the control consumed 46.67 ± 2.97 g/day of feed which was second to the highest, following the rabbits in group T_5D, its water to feed ratio was the least. This implied that the high ratio of water consumption to feed of rabbits fed the biodegraded sweet orange peel based diets was caused by the nature of the test ingredient which had a higher crude fibre content than maize. The non-significant ($p>0.05$) difference in the final body weight, weight gain and feed intake of rabbits among the treatment groups showed that the biodegradation of sweet orange peel using rumen filtrate improved its feed value and hence, can be used to replace dietary maize in the diet of rabbit. This was similar to what was has been reported (14) when growth of rabbits was enhanced by replacing 30% maize within biodegraded sweet orange peel. The non-significant ($p>0.05$) variation from 3.16 to 3.59 in FCR of rabbits fed biodegraded sweet orange peel compared favourably with the control with FCR of 3.36. This is an indication of comparable utilization of the experimental diets. This showed that the rabbits fed the biodegraded sweet orange peel were able to transform and convert nutrients present in the biodegraded peels into lean meat like control. The FCR in this study, although was not significant was better than those reported by previous authors (FCR of 4.21 to 4.57 (15), 4.73 to 5.36 (16) and 4.54 to 6.95 (17)) with different processing techniques of sweet orange peels fed as a replacement for maize in grower rabbit diet. The possibility is therefore high that the methods adopted in processing of SOP may have affected their feed value thereby affecting the quality of nutrients available for utilization.

The effects of the experimental diets on haematological and serum biochemical indices are presented in Table 3 and Table 4, respectively. Replacement of maize with biodegraded sweet orange peel did not cause any significant effect ($p>0.05$) on any of haematological indices. The PCV, WBC, Hb, MCV and MCHC were within the normal range of 30 to 50%, 4.5 to 11×10^9/l, 10 to 15g/dl, 78 to 95fl and 27 to 37g/dl, respectively (18). RBC and MCH were within the normal range of 3.7 to 7.5×10^{12}/l and 19.2 to 29.5pg, respectively (19). Haematological indices provide essential information on the physiological status of animals and, they are related to blood and blood forming tissues. Blood act as pathological reflector of the status of exposed animals to toxicants and other conditions (20). It has been reported (21) that animals with good blood composition are

likely to show good performance. The haematological result showed that 30% replacement of maize with biodegraded SOP did not stimulate any negative haematological response in the rabbits. This may be responsible for the apparent good health condition of the experimental rabbits. The diets caused significant variation ($p<0.05$) in the levels of the two liver enzymes serum alanine aminotransferase (ALT) and aspartate aminotransferase (AST) determined, across the treatment groups but had no significant effect ($p>0.05$) on total protein, albumin, globulin, cholesterol and creatinine. Although, the difference observed in these enzymes had no particular sequence, the significant variation in the concentration of these enzymes is an indication that the nature of the experimental diets which was influenced by the presence of the biodegraded sweet orange peel may have affected their synthesis. Serum biochemistry provides useful information about visceral organ damage especially for the liver and kidney (22). The values of ALT and AST for both the control group and the biodegraded sweet orange peel were above the normal range of 5 to 9 u/l and 6 to 20 u/l with the exception of the grower rabbits in the control dietary group with AST level of 14.93±10.20u/l. It was however, observed that the levels of AST were higher than ALT which is consistent with other reports (24, 25). The values obtained for serum biochemical constituents namely; total protein, albumin, globulin and creatinine in the study were comparable to the values of 4.5-12.2g/dl, 2.7-4.3g/dl, 1.8-7.9g/dl and 1.08-2.52mg/dl, respectively reported for healthy rabbits (23). This suggests that the health of the grower rabbits were not affected adversely as a result of dietary replacement of maize with biodegraded sweet orange peel.

Table 2: Effect of experimental diets on the performance of grower rabbits (mean±SE)

	Experimental Diets					
Parameters	D	T_1D	T_2D	T_3D	T_4D	T_5D
IBW (g)	349.67±43.98	376.17±38.61	373.33±28.22	373.33±35.43	389.00±32.32	398.80±42.37
FBW (g)	1529.00±18.39	1579.50±76.04	1458.17±83.00	1600.00±79.68	1519.00±11.97	1697.80±71.30
FI (g/day)	46.67±2.97	44.64±1.63	45.00±1.31	45.68±0.83	44.67±2.70	47.59±1.88
BWG (g/day)	14.03±1.66	14.32±6.74	12.91±1.00	14.61±0.67	13.46±1.16	14.03±1.29
WI (ml/day)	$137.43±62.72^{b}$	$187.46±8.21^{ab}$	$167.14±11.18^{ab}$	$181.12±6.64^{ab}$	$175.05±8.69^{ab}$	$195.04±11.57^{a}$
FCR	3.36±0.20	3.51±0.17	3.59±0.30	3.16±0.10	3.39±0.30	3.47±0.25
Water:Feed (ml/g)	2.94±0.29	4.20±0.13	3.70±0.20	3.96±0.00	3.93±0.10	4.09±0.12
Mortality	3	0	0	0	1	0

[a,b] Means with different superscripts on the same row are significantly different ($p<0.05$), SE= Standard error
D= Control diet
T_1D= Diet containing 1 LitreRF: 5.00kg SOP fermented for 48hours and sun-dried
T_2D= Diet containing 1 LitreRF: 2.50kg SOP fermented for 48hours and sun-dried
T_3D= Diet containing 1 LitreRF: 1.67kg SOP fermented for 48hours and sun-dried
T_4D= Diet containing 1 LitreRF: 1.25kg SOP fermented for 48hours and sun-dried
T_5D= Diet containing 1 LitreRF: 1.00kg SOP fermented for 48hours and sun-dried
IBW = Initial body weight
FBW = Final body weight
FI = Feed intake
BWG = Body weight gain
WI = Water intake
FCR = Feed conversion ratio

Table 3: Effect of experimental diets on haematological indices of grower rabbits (mean± SE)

Parameters	D	T_1D	T_2D	T_3D	T_4D	T_5D
PCV (%)	37.33±3.71	40.00±1.15	37.00±4.04	42.67±4.37	46.00±2.30	46.00±1.15
RBC (10^{12}/L)	6.13±0.37	4.97±0.29	4.90±0.47	5.37±0.31	3.80±0.35	6.00±0.50
WBC (10^9/L)	4.33±1.04	2.27±0.13	3.67±1.07	2.73±0.64	3.80±0.61	5.20±2.30
Hb (g/dl)	15.77±1.25	13.33±0.38	12.33±1.36	14.20±1.46	15.57±0.81	15.33±0.38
MCV (fl)	77.67±7.32	86.33±1.33	76.27±8.94	80.93±12.13	77.60±0.80	77.40±57.94
MCH (pg)	25.87±2.49	27.00±1.40	25.43±3.03	26.77±4.23	26.27±0.30	25.80±1.48
MCHC (g/dl)	33.33±0.33	33.33±0.33	33.30±0.57	33.27±0.33	33.80±0.45	33.33±0.33

SE=Standard error

PCV= Packed cell volume, RBC= Red blood cell, WBC= White blood cell, Hb= Haemoglobin, MCV= Mean corpuscular volume, MCH= Mean cell haemoglobin, MCHC= Mean corpuscular haemoglobin concentration.

D= Control diet

T_1D= Diet containing 1LitreRF: 5.00kg SOP fermented for 48 hours and sun-dried

T_2D= Diet containing 1LitreRF: 2.50kg SOP fermented for 48 hours and sun-dried

T_3D= Diet containing 1LitreRF: 1.67kg SOP fermented for 48 hours and sun-dried

T_4D= Diet containing 1LitreRF: 1.25kg SOP fermented for 48 hours and sun-dried

T_5D= Diet containing 1LitreRF: 1.00kg SOP fermented for 48 hours and sun-dried

Table 4: Effect of experimental diets on serum biochemical values of grower rabbits (mean ± SE)

Parameters	D	T_1D	T_2D	T_3D	T_4D	T_5D
Total Protein (g/dl)	4.43±0.23	5.20±1.35	4.00±0.10	4.27±0.13	4.07±0.38	4.17±0.24
Albumin (g/dl)	4.07±0.89	3.03±0.38	3.23±0.14	3.87±0.89	2.93±0.71	3.57±0.03
Globulin (g/dl)	0.37±0.18	2.17±1.43	0.77±0.09	0.40±0.17	1.13±0.38	0.60±0.26
Cholesterol (mg/dl)	110.07±11.17	111.47±8.31	121.33±18.96	137.43±26.79	104.73±5.94	116.47±6.20
Creatinine (mg/dl)	2.07±0.33	2.13±1.03	1.17±0.69	1.40±0.55	1.83±0.42	0.73±0.32
ALT (iu/l)	$10.43±8.73^b$	$17.23±11.42^b$	$54.50±11.06^a$	$20.33±10.09^b$	$26.27±10.16^{ab}$	$25.63±4.54^{ab}$
AST (iu/l)	$14.93±10.20^a$	$71.53±18.49^{ab}$	$64.67±8.94^a$	$83.80±29.22^{ab}$	$129.10±28.55^{ab}$	$128.53±24.17^{ab}$

^{a,b} Means with different superscripts on the same row are significantly different ($p<0.05$)

ALT= Alanine aminotransferase; AST= Aspartate aminotransferase

SE= Standard error.

D= Control diet

T_1D= Diet containing 1LitreRF: 5.00kg SOP fermented for 48 hours and sun-dried

T_2D= Diet containing 1LitreRF: 2.50kg SOP fermented for 48 hours and sun-dried

T_3D= Diet containing 1LitreRF: 1.67kg SOP fermented for 48 hours and sun-dried

T_4D= Diet containing 1LitreRF: 1.25kg SOP fermented for 48 hours and sun-dried

T_5D= Diet containing 1LitreRF: 1.00kg SOP fermented for 48 hours and sun-dried

Conclusion and Application

1. Dietary replacement of 30% maize with sweet orange peel subjected to a 48-hour biodegradation with bovine rumen filtrate at ratio 1:1, improved its feed value for grower rabbits compared to those on the maize based diet.

2. Grower rabbits can be fed with diet in which 30% maize is replaced, with biodegraded sweet orange peel obtained from 48 hours fermentation when mixed with bovine rumen filtrate, at ratio 1:1 to obtain a superior growth performance.

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