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THE EFFECT OF BIODEGRADATION ON SWEET ORANGE PEEL AND ITS FEED VALUE IN STARTER BROILER CHICK'S DIET

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Abstract: A twenty-eight-day feeding trial was conducted to evaluate maize replacement value of rumen filtrate biodegraded sweet orange peel (SOP) in the starter broiler chick's diet. Sweet orange fruit peels were collected from retailers of peeled sweet orange fruits. Fresh rumen content was collected from a government abattoir, mixed with water at the ratio of 1 kg: 1 liter, and the mixture sieved to obtain rumen filtrate (RF). Rumen filtrate was mixed with sweet orange peels at the ratio of 1 liter: 2.5 kg, poured into polythene bags, tied at the open end, and allowed a 48-hour for biodegradation. The fermented sweet orange peels were sun-dried to about 10% moisture, milled and incorporated into each of five broiler starter diets as a replacement for maize at levels of 0%, 5%, 10%, 15%, and 20% to give diets T1, T2, T3, T4, and T5, respectively. Biodegraded SOP contained 8.80% crude protein, 13.25% crude fibre, 8.65% ether extract, 9.90% ash, and 59.40% NFE, and metabolizable energy of 3720.67 Kcal/kg. The experimental diets had significant effect ($P<0.05$) on daily feed intake, final body weight and body weight gain. There was no significant difference ($P>0.05$) among other performance indices measured across the dietary treatments. Dietary incorporation of SOP meal as a replacement for maize did not support the growth of starter broiler chicks, and further studies are necessary to investigate other processing methods that can further reduce its fibre content, to enhance its feed value as a replacement for maize in the diets of broiler chicks.

Keywords: Sweet orange peel, Biodegradation, Feed value, Growth response, Chicks

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1. Introduction

The poultry industry offers a quick solution for providing the thronging population with the necessary animal protein. Broiler birds are probably the most universal and important of all poultry as producers of meat for human consumption. Animal protein shortage in the diet of the average Nigerian is shown in the consumption of 3.24g per caput which is far below the 35g daily requirement recommended by FAO (Hon et al., 2009). Energy is key to metabolism and if it is limited, dietary protein will be used inefficiently as another source of energy instead of being converted into body protein, hence, adequate energy must be supplied by the diet to make efficient use of dietary protein. Some agro-industrial by-products like composite mango fruits reject (Orayaga, 2016), palm oil sludge (Famurewa and Olarewaju, 2013), citrus by-products like sweet orange peel meal (Oluremi et al., 2018) have been used in non-ruminant animal's diets to partly replace cereals. Sweet orange (*Citrus sinensis*) fruit peel is an agricultural produce waste in Nigeria and with no cost attached to it, and it is high in energy (Oluremi et al., 2010). Rumen content is another important agricultural by-product, in the abattoir industry in Nigeria (Ahemen and Zahradden, 2010) and can be converted into beneficial use by taking advantage of its microbial population rather than its present status as agricultural waste (Oluremi et al., 2010). Its utilisation by taking advantage of its microbial content for the processing of sweet orange fruit (*Citrus sinensis*) peel can result in value addition to the peel to increase its suitability as a dietary energy source for livestock production. This study aimed to determine the effect of partial replacement of dietary maize with graded levels of bovine rumen filtrate-treated sweet orange (*Citrus sinensis*) fruit peel meal on the performance response of starter broiler chicks.

2. Materials and Methods

2.1. Study Area

The study was carried out at the Poultry Unit of the Livestock Teaching and Research Farm of the College of Animal Science, Federal University of Agriculture Makurdi, Benue State, Nigeria. Makurdi is situated in the north-central zone of Nigeria with a latitude of 7°.43´N and a longitude of 8°.53´N (Microsoft Encarta 2008).

2.2. Test Ingredients Collection and Preparation

Sweet orange fruit peels were collected from some sweet orange retail sellers around the Makurdi metropolis. Fresh rumen content was collected from cattle immediately after slaughter at the government-owned Wurukum Abattoir. Rumen content was mixed with water at a ratio of 1 kg: 1 liter, and thereafter sieved to obtain rumen filtrate (RF). The rumen filtrate was mixed with sweet orange peels at the ratio of 1 liter: 2.5 kg, and the mixture put in polythene bags, tied at the open end, allowed a 48-hour biodegradation, and sun-dried to below 10% moisture for safe storage before final use in diet preparation. The sun-dried sweet orange peel material was milled, analyzed for proximate constituent using the standard methods (AOAC, 2015), and used in formulating starter diets replacing maize at levels of 0%, 5%, 10%, 15%, and 20% to give diets T_1, T_2, T_3, T_4, and T_5, respectively as shown in Table 1.

2.3. Experimental Animal, Design and Procedure

A hundred and fifty (150) day-old, unsexed broiler chicks were used for this experiment. The birds were weighed and grouped into five (5) equal numbers and similar live weights. Each group was randomly assigned to one of the five (5) dietary treatments T_1, T_2, T_3, T_4, and T_5. There were 3 replicates per treatment with 10 birds per replicate. Each treatment replicate was randomly allotted to the experimental pens. The experiment was a completely randomized design. The birds were raised in a deep litter of wood shavings. Feed and drinking water were provided ad libitum, and standard routine management practices (feeding, watering, and washing of drinkers, cleaning of feeders, and pen passages) were followed. The birds were vaccinated against Newcastle disease (i/o) at day old, infectious bursal disease at day 14, Newcastle disease (Lasota) at day 21, and infectious bursal disease at day 28 as recommended by the manufacturer, National Veterinary Research Institute, Vom - Jos, Nigeria. An anti-stress supplement which contains vitamins A, B_1, B_{12}, C, D_3, E, Biotin and Niacin, was administered prior to and after each vaccination, and pre-and post-weekly weighing of the birds, to maintain the optimum level of vitamins, reduce mortality due to stress, improve vaccination titre, enhance immune response and improve growth. Coccidiostat was administered at alternate weeks to stem the occurrence of coccidiosis which is endemic in the study environment, and antibiotics was given if and when necessary as prophylactics. Data collected was used for the evaluation of growth performance.

Table 1. Ingredients composition of experimental diets for starter broiler chicks

	Experimental Diets				
Ingredients (kg/100kg)	T1	T2	T3	T4	T5
Maize	49.22	46.76	44.30	41.84	39.38
SOP	-	2.46	4.92	7.38	9.84
Soybean meal	37.08	37.08	37.08	37.08	37.08
Maize offal	4.30	4.30	4.30	4.30	4.30
Brewers dried grain	4.00	4.00	4.00	4.00	4.00
Bone ash	2.00	2.00	2.00	2.00	2.00
Fish meal	0.70	0.70	0.70	0.70	0.70
Limestone	1.20	1.20	1.20	1.20	1.20
Palm oil	0.50	0.50	0.50	0.50	0.50
Broiler Premix*	0.25	0.25	0.25	0.25	0.25
Common salt	0.25	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.30	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00	100.00
Calculated analysis					
ME (Kcal/kg)	2855.66	2841.44	2827.23	2813.01	2800.78
Crude protein (%)	22.73	22.70	22.66	22.63	22.60
Ether extract (%)	4.21	4.18	4.14	4.11	4.08
Crude fibre (%)	4.73	4.94	5.16	5.36	5.56
Calcium (%)	1.60	1.60	1.60	1.60	1.60
Avail. P (%)	0.72	0.72	0.71	0.70	0.69
Lysine (%)	1.10	1.09	1.09	1.08	1.07
Methionine (%)	0.37	0.37	0.36	0.36	0.35
Cost/Kg diet ($)	0.38	0.37	0.36	0.35	0.34

SOP= sweet orange peel meal, BDG=body weight gain, T1= 0% maize replacement with SOP (Control diet), T2= 5% maize replacement with SOP, T3= 10% maize replacement with SOP, T4= 15% maize replacement with SOP, T5= 20% maize replacement with SOP.

2.4. Statistical Analysis

Data collected were subjected to a one-way analysis of variance (ANOVA) using SPSS (2012), and the means of significantly different (P<0.05) parameters were separated using Duncan's Multiple Range Test (DMRT) of the same package (Genç and Soysal, 2018).

3. Results

The chemical composition of the biodegraded sweet orange peel meal is presented in Table 2. The SOP contained dry matter (DM) content of 92.5%, 8.80% crude protein (CP), 13.25% crude fibre (CF), 8.65% ether extract (EE), 9.90% ash and 59.40% nitrogen-free extract (NFE). The effect of the experimental diet on the performance response of broiler chicks is shown in Table 3. The initial live weight of the chicks varied from 46.59g to 47.74g with no significant (P>0.05) difference among the treatments. However, there were significant differences (P<0.05) among treatments in the final body weight, average body weight gain and daily feed intake of the birds fed graded levels of biodegraded sweet orange peel meal. The experimental diets did not have a significant effect (P>0.05) on feed conversion ratio, protein intake and protein efficiency ratio and mortality among the treatment groups. The chicks in T1 (control) had the highest feed intake of 36.19g which was significantly different (P<0.05) from chicks in T5 while the chicks in T5 recorded the lowest feed intake of 28.22g. The broiler chicks in T1 performed significantly (P<0.05) better in final body weight than other treatments while, its daily body weight gain was only significantly (P<0.05) better than chicks on diet T4 and T5 containing 15 % and 20 % of biodegraded sweet orange peel meal in their diets respectively.

Table 2. Proximate composition of biodegraded sweet orange peel meal (% DM)

Nutrients (% DM)	Sweet orange peel meal[1]	Maize[2]
Dry matter	92.50	86.50
Crude protein	8.80	9.00
Crude fibre	13.25	1.30
Ether extract	8.65	4.00
Ash	9.90	2.70
Nitrogen free extract	59.40	83.00
[3]Metabolizable energy (Kcal/kg)	3720.67	3432.00

[1]Laboratory Analysis, [2]Aduku (2005), [3]Metabolizable energy as determined using Carpenter and Clegg (1956).

Table 3. Effect of biodegraded sweet orange peel meal on the growth response of starter broiler chick (day old – 28 day old)

	Experimental Diets					
Parameters	T1	T2	T3	T4	T5	SEM
Initial body weight (g/bird)	47.02	47.74	47.29	46.59	46.88	0.42^{ns}
Final body weight (g/bird)	525.37^{a}	468.48^{b}	466.17^{bc}	427.77^{c}	406.10^{c}	14.19*
BWD (g/day/bird)	17.08^{a}	15.03^{ab}	14.96^{ab}	13.62^{b}	12.83^{b}	0.51*
Feed intake (g/bird/day)	36.19^{a}	29.63^{ab}	31.94^{ab}	29.80^{ab}	28.22^{b}	1.07*
Feed conversion ratio	2.12	1.96	2.15	2.19	2.19	0.04^{ns}
Protein intake (g/bird/day)	8.40	6.87	7.39	6.90	6.51	0.25^{ns}
Protein efficiency ratio	2.03	2.20	2.03	1.97	1.98	0.04^{ns}
Mortality rate (%)	0.67	0.00	0.00	0.33	0.00	0.11^{ns}

^{a,b,c}Means with different superscripts in the same row are significantly different (P<0.05), *(P<0.05), ^{ns}Not significantly different (P>0.05), SEM= standard error of mean, SOP= sweet orange peel meal, BDG= daily body weight gain, T1= 0% maize replacement with SOP (Control diet), T2= 5% maize replacement with SOP, T3= 10% maize replacement with SOP, T4= 15% maize replacement with SOP, T5= 20% maize replacement with SOP.

4. Discussion

The proximate composition of biodegraded sweet orange fruit peel meal showed it contained 92.5% DM, 8.80% CP, 13.25% CF, 8.65% EE, 9.90% ash, and 59.40% NFE. Ojabo et al. (2014) reported a DM of 86.20%, 7.40% CP, 8.19% ash, 7.19% EE, 13.50% CF, 62.65% NFE and 3674.44 Kcal/kg ME for sundried sweet orange peel meal. Agu et al. (2010) reported 89.65% DM, 10.74% CP, 7.86% ash, 12.00% EE, 11.90% CF, 56.91% NFE and 3988.70 kcal/kg ME. Also, 7.0 % CP, 12.50% CF, and ME of 3420 kcal/kg were reported by Ashbell and Weinbegger (1999) in Israel for sweet orange peel. The crude fibre level in SOP the test ingredient is high, like what has been reported by some other workers. The nutrient quality of feed ingredients is one of the major prerequisites for the production of good-quality feeds. The basic nutrients that cannot be compromised in the choice of ingredients for

feed formulation are protein and energy. The dry matter of 92.28% in this study was higher than 87.60% for sweet orange peel (SOP) biodegraded with rumen content for 48 hours reported by Oluremi et al. (2008). The possible anti-nutritional factors of sweet orange peels are phytic acid, saponin, tannin, and oxalate, they can interfere with digestive processes and prevents effective absorption and utilization of micro/macro nutrients, but these can be prevented by some processing methods such fermentation, chemical treatments, sun-drying, soaking and various other processing methods which helps to prevent/lower the effect of these antinutritional factors and improve the nutritive value of sweet orange peel.

The SOP meal with a CP of 8.80% was higher than 7.40% reported by Ojabo et al. (2014), and 7.50% by Akpe et al. (2019). The disparity in crude protein composition could be attributed to the type of pasture consumed by the cattle which will affect the type and the population of the ruminal microorganism, the ratio of rumen content to sweet orange peel used for processing, and the stage of digesta degradation in the rumen when cattle was slaughtered. The CP is however slightly lower than CP in maize, a conventional energy feedstuff with 9.10% CP (Aduku, 2005), while crude fibre (CF) of 13.25% in the peel was lower than 13.50 % and 14.60% reported by Ojabo et al. (2014) and Ani et al. (2015), respectively. The slight reduction may be due to the processing method used in this study. The high CF in the peel may reduce its feeding value compared to conventional dietary maize in poultry nutrition, even though it has a high metabolizable energy of 3720.67 kcal/kg. The high CF content in the biodegraded SOP in this study most probably caused the reduction of its NFE, the digestible carbohydrate and energy nutrient in feed ingredients. Hence, the energy yield of biodegraded SOP will be of inferior value compared to that of maize in practical broiler chicken feeding.

The ash content of 9.90% obtained in this study was higher than 4.47% (Ani et al., 2015), and 8.19% (Ojabo et al., 2014). The implication of the high ash content is that it may lower the dietary caloric yield because of the limitation of mineral elements to yield energy in the metabolic process of oxidation. Therefore, the results of the proximate composition of biodegraded SOP meal showed that, while its high crude protein content can be of nutritional benefit to monogastric animals, including broiler chicken, its content of crude fibre and ash can be adverse to the good performance of these farm animals.

The highest feed intake of 36.19 g was lower than 56.16 g reported by Oluremi et al. (2010) who fed fermented sweet orange peel-based diets to broiler chicks, and 37 g reported by Aduku (2005) as the mean daily feed intake for starter broiler chicks. This may be attributed to the low fibre content of the control maize-based diet (T1) compared to the high fibre content in the biodegraded SOP meal-based diets, the overall feed composition, dietary nature, and strain/breed of broiler chicks used. Abbas et al. (2013) also reported dietary fibre effect on broiler chicks fed sweet orange peel-based diet. The body weight gain, like the feed intake of the chicks, significantly ($P<0.05$) decreased as the percent maize replacement with biodegraded SOP increased from 0% to 20%. Consequently, the daily weight gain was highest in T1 (17.08 g) and lowest in T5 (12.83 g). The range was less than 32.44 g to 43.17 g (Medugu et al., 2010) but comparable with 11.97 g to 21.70 g (Oluremi et al., 2010). Furthermore, feed intake appeared to have a direct effect on body weight gain and, thus, a cumulative effect on the final body weight. Feed intake and utilization of the nutrients present are the major factors influencing both body weight gain and feed efficiency in meat-type birds. The final body weight of the chicks was significantly ($P<0.05$) different among the dietary groups decreasing from T1 (525.37 g) to T5 (406.10 g) for the same reason as for body weight gain.

The experimental diets did not have any significant ($P>0.05$) effect on feed conversion ratio, protein intake, protein efficiency ratio, and mortality rate across the dietary groups. This showed that the replacement of maize with biodegraded SOP in the range of 0% to 20% did not negatively impact on the quantitative values of all these performance indicators in the starter broiler chicks. The rate of mortality among the experimental birds in this study was less than 5% regarded as normal for broiler chicks (Oluyemi and Roberts, 2000). Furthermore, since mortality did not show any significant difference among the dietary treatments, biodegraded SOP meal may be a safe ingredient to use in compounding broiler chick diet if its other nutritional limitations can be mitigated.

5. Conclusion

From the result obtained in this study, it was concluded that the rumen filtrate biodegraded sweet orange peel meal is comparable with maize in crude protein and higher in metabolizable energy content but inferior in crude fibre and can thus be transformed from being an agricultural waste into a feed resource in broiler chicken production. The utilization of SOP meal as replacement maize did not support the growth of starter broiler chicks, and further studies are therefore necessary to investigate other processing methods that can further reduce the fibre content of sweet orange peel meal to enhance its feed value as a replacement for maize in the diets of broiler chicks.

Author Contributions

The percentage of the author(s) contributions is present below. All authors reviewed and approved final version of the manuscript.

	E.T.A.	O.O.	K.C.O.
C	100		
D	40	30	30
S		50	50
DCP	100		
DAI	100		
L	40	30	30
W	50	50	
CR		100	
SR	75	25	
PM	50	50	
FA	100		

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to. The experimental procedures were approved by the Local Animal Care and Ethics Committee of the Federal University of Agriculture, 2373, Makurdi, Nigeria.

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