Journal of Animal Husbandry and Dairy Science
Volume 4, Issue 1, 2020, PP 23-29
ISSN 2637-5354

The Effect of Biodegraded Sweet Orange (*Citrus Sinensis*) Fruit Peel on the Growth and Economic Performance of Starter Broiler Chicks

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ABSTRACT

A twenty-eight (28) day feeding trial was conducted to evaluate the effect of the use of cattle rumen content (RC) for the biodegradation of fresh sweet orange peels (SOP) on its maize replacement value in broiler starter diet. Two hundred and sixteen (216) Marshal broiler chicks, randomly allocated to six (6) dietary treatments were used. Each treatment had three (3) replicates and each replicate had twelve (12) randomly allocated to the experimental pens. The experiment was completely randomized design. Five (5) different biodegraded sweet orange peels (BSOP) T1, T2, T3, T4 and T5 were obtained after mixing sweet orange peels and rumen content w/w in ratio 1 SOP: 0.1 RC, 1 SOP: 0.2 RC, 1 SOP: 0.3 RC, 1 SOP: 0.4 RC and 1 SOP: 0.5 RC, respectively and, each was put in tied polythene bag, left to ferment for 48 h and sun dried to about 10% moisture. Each of T1, T2, T3, T4 and T5 was used to replace maize at 20% level in the control diet (D1) to obtain diets D2, D3, D4, D5 and D6, respectively. The experimental diets and drinking water were served ad libitum, and growth performance and economic indices determined. The result showed that, the broiler chicks in the control diet (D1) had significantly ($p<0.05$) better growth performance in body weight, weight gain, FCR, protein intake and protein efficiency ratio than the chicks in the BSOP dietary treatments. Chicks in group D6 had a superior growth performance in body weight, weight gain, FCR, protein intake, and protein efficiency ratio, among the sweet orange peel based diets. Chicks in D1 had a significantly ($p<0.05$) higher total cost of production ($2.55), followed by D6 ($2.43) and D3 had the least ($2.34) with proportionate growth rate. It is recommended that sweet orange peel (SOP) can be treated with cattle rumen content (RC) in the ratio of 1 SOP: 0.5 RC w/w, and used to replace 20% maize in broiler starter diets for growth and economic benefits.

Keywords: *Biodegraded sweet orange peels, broiler chicks, growth, economic performance.*

INTRODUCTION

The poultry industry in most developing countries in Africa like Nigeria, which is synonymous with the raising of *Gallus gallus domesticus* for meat and egg production continues to experience feed crisis. This is partly due to the explosion in human population in Africa put at 1.34 billion (World meter, 2020), and the consequent pressure on the available foodstuffs some of which are critical to compound the diets of chickens due to their high feed value. The spiral competition between man and his chickens which supplies the much needed animal protein for good health and balanced development is threatening the survival of the poultry industry. Animal protein is particularly essential in human nutrition because of its biological significance and thus the need to come up with viable alternatives to the conventional feed materials. In non-ruminant animal feeding, energy is the main driving force of metabolism and if energy is limiting, 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 *et al.*, 2013), citrus by-products like sweet orange peel meal (Oluremi *et al.*, 2018) have been used in non-ruminant animals' diets to partly replace cereals. Due to their low cost and easy availability such wastes are capable of offering significant low-cost nutritional dietary supplements. A number of agro-industrial by-products are generated from fresh citrus after the main product of interest (juice) has been removed or extracted during processing for direct human consumption as in the case of developing countries (Oluremi *et al.*, 2007a). The utilization of these bioactive rich citrus residues can result in a safe environment for man, as against the present practice of indiscriminate dumping which constitutes hazards to man because of generation of odorous gases and blockage of drains causing flooding. Sweet orange (*Citrus sinensis*) fruit peel is abundant in Nigeria all year round, and has been reported to be high in crude fibre and energy (Oluremi *et al.*, 2010). Studies applying simple cost effective techniques to improve its feed value in the nutrition of rabbit by using rumen content an organic microbial waste found in abattoirs are on-going to produce a bio-friendly alternative energy feedstuff Oluremi *et al*. (2018). This study was therefore aimed at evaluating the use of the rumen content of cattle which is an abundant animal processing by-product for the enhancement of the feed value of sweet orange fruit peel in raising starter broiler chicks.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted in the Poultry unit at the Livestock Teaching and Research Farm, Federal University of Agriculture Makurdi, Benue state, Nigeria. The geographical coordinates are longitude 7° 47′ and 10° 0′ east, latitude 6°25′ and 8°8′ north. The State shares a common boundary with the Republic of Cameroun on the south-east (www.nigeria.gov.ng/2012).

The Source and Preparation of Sweet Orange Peel

Sweet orange (*Citrus sinensis*) fruit peels which was the test ingredient (Plate I) were collected from sweet orange fruit retailers within the university town of Makurdi. They usually peel the orange fruit before selling to consumers. Rumen content (Plate II) was collected from freshly slaughtered white Fulani cattle at the Wurukum abattoir in Makurdi. The collected sweet orange peels (SOP) was then mixed thoroughly (Plate III) with the rumen content (RC) in weight proportions of 1 SOP : 0.1 RC (T2), 1 SOP : 0.2 RC (T3), 1 SOP : 0.3 RC (T4), 1 SOP : 0.4 RC (T5) and 1 SOP : 0.5 RC (T6). Each mixture was tied in a black polythene bag and allowed to ferment for 48hours. The differently biodegraded sweet orange peels (BSOP) were then sun dried (Plate IV), to about 10% moisture. The dried rumen content was removed and the peels milled. Each of T2, T3, T4, T5 and T6 was used to replace maize in the control diet (D1) at 20% to obtain starter diets D2, D3, D4, D5 and D6 (Table 1).

Plate I: *Fresh sweet orange peels*

Plate II: *Cattle rumen content*

Plate III: *Mixing of Sweet orange peels with rumen content*

Plate IV: *Sun dried biodegwdraded sweet orange peels*

Table 1: *Ingredients and Dietary Composition of Broiler Starter Diets.*

	Experimental Diets					
Ingredients	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**
Maize	52.50	42.00	42.00	42.00	42.00	42.00
BSOP	10.50	10.50	10.50	10.50	10.50	10.50
Soybean meal	36.60	36.60	36.60	36.60	36.60	36.60
Blood meal	1.50	1.50	1.50	1.50	1.50	1.50
Brewer dried grains	5.00	5.00	5.00	5.00	5.00	5.00
Bone ash	2.00	2.00	2.00	2.00	2.00	2.00
Limestone	1.50	1.50	1.50	1.50	1.50	1.50
Premix*	0.25	0.25	0.25	0.25	0.25	0.25
DL-Methionine	0.20	0.20	0.20	0.20	0.20	0.20
L-Lysine	0.20	0.20	0.20	0.20	0.20	0.20
Common salt	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100
Calculated nutrients						
Crude protein (%)	23.70	23.65	23.65	23.65	23.65	23.65
Crude fat (%)	2.98	3.13	3.13	3.13	3.13	3.13
Crude fibre (%)	3.96	4.56	4.56	4.56	4.56	4.56
Calcium (%)	1.41	1.41	1.41	1.41	1.41	1.41
Phosphorus (%)	0.73	0.70	0.70	0.70	0.70	0.70
M. E (kcal/kg)	2883.70	2875.20	2875.20	2875.20	2875.20	2875.20

**Animal care premix premix supplied per kg of feed: vit A 12, 000 iu, Vit D3 3000 iu, Vit E. 30mg, Vit k 2.5mg, Riboflavin 4mg, Vit B120.01mg, Panthotenic acid 5mg, Niacin 40mg, Folic acid 10mg, Selenium 2.5mg, Chlorine 30mg, Manganese 70mg, Iron 40mg, Copper 80mg, zinc 60mg, Cobalt 125mg, Iodine 120mg.*

D1=Control diet.

D2= Diet contained 20% maize replacement with T2.

D3= Diet contained 20% maize replacement with T3

D4= Diet contained 20% maize replacement with T4

D5= Diet contained 20% maize replacement with T5

D6= Diet contained 20% maize replacement with T6

BSOP = Biodegraded sweet orange peel

Experimental Birds and Management

A total of two hundred and sixteen (216) Marshal MY broiler chicks were purchased from Chi Farms, Ibadan, Nigeria and used for the study. The chicks were randomly allocated to 6 dietary treatments, replicated three (3) times with each replicate containing 12 birds. Each replicate was also randomly allocated to the experimental pens. The experiment was completely randomized design. The experimental chicks were raised in a half-walled deep litter house to allow for good ventilation. The experimental diets and cool drinking water were supplied to the birds *ad libitum* for a 28-day starter phase. Vaccines were given at day-old against Newcastle disease (i/o), at 8th day against infectious bursal disease (gumboro) and repeated at 15th day and, at 21st day against Newcastle disease (lasota). Vitalyte, an anti-stress was given pre and post vaccination. Prococ, a coccidiostat was given at alternate weeks to control outbreak of coccidiosis which is endermic in the area. Oxy-200, an antibiotic was given periodically to prevent bacterial infection. Drinkers were washed with detergent every morning before drinking water was supplied to the experimental birds.

Growth and Economic Performance Parameters

Initial and final weights of broiler chicks were taken per replicate at the start of the feeding trial and at the termination, respectively with a 10 kg sensitive weighing scale. Weekly weights were taken to determine body weight gain (BWG) by difference. Feed intake (FI) was determined weekly by difference between the weight of the feed supplied for the week and the left over. Feed conversion ratio (FCR) was calculated as ratio of feed intake to body weight gain {FI/BWG}. Water intake was determined as recommended by Shoremi *et al.* (1997) which took evaporative water loss into consideration. Protein intake (PI) was calculated as total feed consumed multiplied by the % crude protein in the diet {ΣFI x % CP}. Protein efficiency ratio (PER) was determined as ratio of body weight gain to protein intake {BWG/PI}. The economic performance was determined using the summation of the amount spent per bird which covered the costs of chick, feed consumed, medications, vaccines, and miscellaneous expenditure by computing:

a. Total cost of production = Cost of day-old chicks + Feed cost + Operational cost

b. Feed cost as percent of total cost of production

$$= \frac{\text{Feed cost}}{\text{Total cost of production}} \times 100$$

c. Cost of day-old chicks as percent of total cost of production

$$= \frac{\text{Cost of day-old chicks}}{\text{Total cost of productiont of production}} \times 100$$

Statistical Analysis

Data collected on each parameter was subjected to one way analysis of variance (AVOVA) using Minitab (2014) and where significant differences occurred, the means were separated using the least significant difference as contained in Minitab (2014).

Results And Discussion

Growth Performance

The effect of the experimental diet on the performance response of starter broiler chicks is shown in Table 2. The experimental diets had significant ($p<0.05$) effect on the mean final body weight, body weight gain, feed intake, feed conversion ratio, protein intake and protein efficiency ratio across the treatments but, had no significant ($p>0.05$) effect on the water intake and water:feed ratio. The chicks in the control group (D1) had the highest final body weight of 1461.80 g while, the birds in D6 with 1319.44 g had the highest among the BSOP based diets. The same trend of variation in which the birds in the control treatment (D1) had the best performance across the treatments, and the birds in D6 had a superior performance among the BSOP treatments was observed in the body weight gain (40.36 g vs 36.48 g), feed intake (66.89 g vs 66.46 g), feed conversion ratio 1.61 vs 1.74), protein intake (16.32 g vs 14.91 g) and protein efficiency ratio (2.47 vs 2.44). The significant difference in the final weight of the chicks showed that the birds in the maize control group were heavier and, among the BSOP treatments final live weight increased as the proportion of rumen content used for biodegradation of the sweet orange peel increased from D2 to D6. Therefore, the proportion of the rumen content used for the biodegradation of the sweet orange peel had a positive effect on its feed value. The result has shown that improvement in the nutritive value of sweet orange peel can be achieved using higher proportion of rumen content which translates to higher microbial density. The mean daily feed intake of 60.55g/day to 66.89g/day for starter broiler chick obtained was higher than 34.02 g/day to 56.16 g/day reported by Oluremi *et al.* (2010) but was within 52.68g/day to 67.56 g/day reported by Agu *et al.* (2010) when unsoaked sun dried sweet orange peel replaced maize at levels of 0 to 50% in broiler starter diets. The feed intake trend obtained showed a relatively higher quantitative intake by the chicks in the control and followed by chicks in D6. The differences in the reported values can be attributed to the different techniques used in processing the sweet orange peel which may have affected its palatability, energy level and the biological value of its protein. Also, the presence and concentrations of anti-nutritional factors can impair the availability of nutrients, depress feed intake and reduce the growth in animals that consume them (Hathcock and Rader, 1994; and Shahidi, 1997). Oluremi *et al.* (2007b) have reported the presence of tannin, saponin, oxalate, phytate, flavonoid and limonene in sun dried sweet orange peels. The average daily body weight gain of 29 .81g to 40.36g for starter broiler chicks was within 34.44g to 43.17g (Medugu *et al.*, 2010) but higher than body weight gain of 11.97 to 21.70g obtained when broiler chicks were fed with fermented sweet orange peel (Oluremi *et al.*, 2010). The body weight gain trend whereby the chicks in the control group (D1) had a comparatively higher value across the treatments, followed by the chicks in D6, D4, D5, D2 and D3 in that order showed that feed intake has a direct impact on body weight gain. It thus appears that there was a commensurate utilisation of nutrients available in the diets for growth. The quality of feed consumed is hence, a major factor influencing body weight gain and feed efficiency in meat-type birds. The fact that the average body weight gain in dietary group D6 was relatively close to the control group D1 suggests an improvement in the feed value of sweet orange peel at higher level of microbial load as a result of increased rumen content incorporation for its biodegradation. The feed conversion ratio (FCR) obtained was better than the range of 2.57-2.88 reported by Oluremi *et* *al.* (2010) and 1.85-2.62 reported by Agu *et al.* (2010), but in agreement with 1.67-1.98 (Ebrahimi *et al.,* 2013). Feed conversion ratio had the same sequence as the feed intake and body weight gain. One of the factors affecting feed conversion ratio is the quality of the feed and this might have contributed to the differences and similarities between the FCR in this study and the earlier studies. As a rule of thumb, FCR is low for young animals when relative growth is large and increases for older animals when relative growth tends to flatten out. Thus, the finding in this study shows that the feed consumed was adequately utilized for growth. The dietary treatments effect on the protein intake indicated superior protein quality of the maize control treatment compared to the BSOP treatments. The latter had similar protein quality. This was effectively reflected in the protein efficiency ratio obtained.

Table2: *Effect of Biodegraded Sweet Orange Peel on Performance of Starter Broiler Chicks*

Performance Indices	Experimental Diets						SEM
	D1	**D2**	**D3**	**D4**	**D5**	**D6**	
Initial body weight (g)	49.00	48.47	49.00	48.10	49.00	48.88	
Final body weight (g)	1461.80^{a}	$11\ 73.61^{cd}$	1075.00^{d}	1201.39^{c}	205.83^{c}	1319.44^{b}	33.08
Body weight gain (g)	40.36^{a}	32.70^{c}	29.81^{d}	33.25^{c}	33.11^{c}	36.48^{b}	0.81
Feed intake g)	66.89^{a}	63.57^{ab}	60.55^{b}	63.62^{ab}	64.38^{ab}	66.46^{a}	1.43
Feed conversion rati (FCR)	1.61^{a}	1.88^{b}	1.93^{b}	1.83^{b}	1.84^{b}	1.74^{b}	0.18
Protein intake (g)	16.32^{a}	14.61^{b}	14.43^{b}	14.90^{b}	14.55^{b}	14.91^{b}	0.33
Protein efficiency ratio	2.47^{a}	2.23^{b}	2.06^{b}	2.22^{b}	2.13^{b}	2.44^{a}	0.06
Water intake (ml)	188.81	181.18	177.88	186.96	182.66	179.04	7.25
Water :Feed Ratio (ml/g)	2.82	2.84	2.93	2.93	2.83	2.69	0.06
Mortality rate (%)	0	0	0	0	0	-	

[a,b,c,d] Means with different superscripts in the same row are significantly different (p<0.05)

SEM = Standard error of mean

D1 = Control diet

D2 = Diet contained 20% maize replacement with T2

D3 = Diet contained 20% maize replacement with T3

D4 = Diet contained 20% maize replacement with T4

D5 = Diet contained 20% maize replacement with T5

D6 = Diet contained 20% maize replacement with T6

The daily water intake values (177.88ml/day to 188.81ml/day) were comparable and within the range of 162.42ml/day to 197.27ml/day reported by Agu *et al.* (2010) when fermented sundried sweet orange peel was incorporated into starter broiler diets. Water is the most essential nutrient in the bird's diet, although a requirement value may not be easily stated. The water consumption of meat- type birds depends on the environmental temperature and relative humidity, the composition of the diet and growth rate. Actual water consumption relative to feed intake varies and meat type birds drink at least twice much water as the amount of feed consumed on a weight basis (Aduku, 2004 and Dafwang, 2009). The water: feed ratio range of 2.69-2.93 obtained in this feeding trial agreed with the finding of these workers. No mortality was recorded, implying that the use of BSOPl was not hazardous to the broiler chicks and did not compromise their survivability.

Economic Performance

The economic implication of raising starter broiler chicks on experimental diets in which 20% of dietary maize was replaced by biodegraded sweet orange peel is presented in the cost of the primary inputs (Table 3) and the economic indices (Table 4). There was no significant (p>0.05) difference among the treatment groups for the feed cost per kg weight gain. However, significant (p<0.05) difference occurred for feed cost of raising a chick from day-old to 28th day. The chicks in D1 had a significantly higher (p<0.05) feed cost of $1.20, followed by D6 among the SOP treatments with a feed cost of $1.08 while, D3 had the least feed cost of $0.99 per chick. The total cost of producing a chick followed the same pattern as the feed cost per chick, whereby the chicks in D1 had a significantly (p<0.05) higher value of $2.55, followed by D6 with $2.43 and D3 having the least total cost of production of $2.34. The feed cost as percentage of total cost of production varied significantly (p<0.05) across the treatment groups. The chicks in D1 had a significantly (p<0.05) higher percentage feed cost (47.00%), while D6 had the highest (44.45%) among the BSOP treatments and, the least was D3 (42.17%). The cost of day-old chicks as percentage of total cost of production was significantly (p<0.05) affected by the diets with the order of variation opposite to the percentage feed cost. Consequently, the chicks in D3 recorded a significantly higher value of 36.37%, while D1 was least (33.33%). The chickens in D1 had the highest feed intake, best body weight gain, feed conversion ratio and the highest feed cost of 47.00% followed by the chickens in D6 the best performing group in the sweet orange peel based diets with a feed cost of 44.45%. The birds with the least performance (D3) in terms of feed intake, body weight gain, feed conversion ratio had the least percent feed cost of 42.17% and had the highest percent cost of day-old chicks (36.37%). This result showed that with higher growth performance of chicks, the percent feed cost increased and percentage cost of day-old chick decreased whereas, with low performance, the reverse occurred. While, lower feed cost per unit weight of bird is an important measure of the economic desirability of a feed resource in non-ruminant animal production, the growth rate is not to be compromised as this determines the duration it takes for the birds to reach the market weight which is a critical production factor for profitability.

Table 3: *Cost of Primary Inputs in Feeding Trial*

Primary inputs	Experimental diets					
	D1	**D2**	**D3**	**D4**	**D5**	**D6**
Starter feed cost ($/kg)	0.51	0.47	0.47	0.47	0.47	0.47
Cost saving by BSOP ($/kg)	-	0.05	0.05	0.05	0.05	0.05
Starter feed cost ($/25kg)	12.80	11.64	11.64	11.64	11.64	11.64
Cost savings by BSOP ($/25kg)	-	1.17	1.17	1.17	1.17	1.17
Cost of day old ($/chick)	0.85	0.85	0.85	0.85	0.85	0.85

D1 = Control diet

D2 = Diet contained 20% maize replacement with T2

D3 = Diet contained 20% maize replacement with T3

D4 = Diet contained 20% maize replacement with T4

D5 = Diet contained 20% maize replacement with T5

D6 = Diet contained 20% maize replacement with T6

BSOP = Biodegraded sweet orange peel

Table4: *Economics of Production of Starter Broiler Chicks on Diets Containing Biodegraded Sweet Orange Peel (Day Old to 28th Day)*

Economic indices	Experimental diets						SEM
	D1	**D2**	**D3**	**D4**	**D5**	**D6**	
FCR (as fed basis)	1.61^a	1.88^b	1.93^b	1.83^b	1.84^b	1.74^b	-
Cost of DOC ($/chick)	0.85	0.85	0.85	0.85	0.85	0.85	-
Starter feed cost ($/kg weight gain)	0.83	0.88	0.90	0.85	0.86	0.81	0.02
Feed cost per chick ($)	1.20^a	1.03^{cd}	0.99^d	1.04^c	1.05^c	1.08^b	0.02
Operational cost ($)[1]	100.26	100.26	100.26	100.26	100.26	100.26	-
Total cost of production ($/chick)	2.55^a	2.38^c	2.34^c	2.39^b	2.40^b	2.43^b	0.02
Cost saving due to BSOP ($/chick)	-	0.17	0.21	0.16	0.15	0.12	-
Feed cost[2] (% of total cost of production)	47.00^a	43.33^b	42.17^c	43.38^b	43.69^b	44.45^b	0.57
Cost DOC[3] (% of total cost of production)	33.33^c	35.64^b	36.37^a	35.61^{bc}	35.42^{bc}	34.94^c	0.35

[a,b,c] Means with different superscripts in the same row are significantly different ($p<0.05$). SEM = Standard error of mean, SOP = Sweet orange peel; [1]Operational cost computed from the cost of housing, energy, medication, vaccination, miscellaneous; [2]Feed cost/total cost X 100; [3] $\frac{Cost\ of\ day-old}{Total\ cost\ of\ production}$ *X 100*

D1 = Control diet

D2 = Diet contained 20% maize replacement with T2

D3 = Diet contained 20% maize replacement with T3

D4 = Diet contained 20% maize replacement with T4

D5 = Diet contained 20% maize replacement with T5

D6 = Diet contained 20% maize replacement with T6

BSOP = Biodegraded sweet orange peel

DOC = Day-old chicks

CONCLUSION

The result obtained has shown that chicks in the maize based control diet treatment have the best growth performance and highest percentage feed cost. The chicks in D6 dietary treatment had the best growth performance and highest percentage feed cost in the biodegraded sweet orange peel dietary treatments which are comparable to control diet. It is recommended that sweet orange peel (SOP) can be treated with cattle ruminal content (RC) in the ratio of 1 SOP:0.5 RC and the biodegraded sweet orange peel obtained used to replace 20% maize in broiler starter diets for a good growth rate.

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Citation: *Oluremi, O. I. A, "The Effect of Biodegraded Sweet Orange (Citrus Sinensis) Fruit Peel on the Growth and Economic Performance of Starter Broiler Chicks", Journal of Animal Husbandry and Dairy Science, 4(1), 2020, pp. 23-29.*