THE FEEDING VALUE OF SWEET ORANGE (CITRUS SINENSIS) FRUIT PEELS FERMENTED WITH BOVINE RUMEN LIQUOR IN BROILER CHICKEN DIETS

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Abstract

A 56-day feeding trial was conducted to determine the effect of bovine rumen liquor fermented sweet orange peel on the feed value of broiler chickens. Fresh rumen content was collected from slaughtered cattle at abattoir, mixed with water in the ratio of 1L: 2.5kg of fresh sweet orange peels (SOP) which was collected from orange sellers within Makurdi metropolis. The mixture was put in polythene bags, tied and left to ferment for 72 hours and then sun-dried. The dried mixture was milled and used to replace dietary maize in the control diet T1 at 5%, 10%, 15% and 20% to obtain diets T2, T3, T4, and T5 respectively. A total of 150, day-old broiler chicks were randomly assigned to five dietary treatments in a Completely Randomized Design and replicated thrice. Broiler chicken fed 5% SOP had significantly (P<0.05) highest final weight, daily weight gain and feed intake although comparable to the control diet. Experimental diets did not show significant effect (P>0.05) on dry matter, crude protein, crude fibre, ash and nitrogen free extract digestibility. The birds in T1 had significantly (P<0.05) highest total cost of production and this decrease with increase in the level of SOP. Likewise, the feed cost per bird was observed to be highest in T1 compared to the birds on experimental diets. The utilization of bovine rumen liquor fermented SOP up to 5% maize replacement had improved performance on the birds and it is recommended that SOP fermented for longer duration beyond 72 hours be evaluated on the feed value of broiler chickens.

INTRODUCTION

1.1 Background

The request for food due to swelling populace is a foremost challenge to the livestock and poultry industry in numerous emerging countries including Nigeria. This is because of the regularly infrequent and unpredictable source of the major feed ingredients, particularly the energy (maize, sorghum, millet) and protein (soybean seed and meal, groundnut cake, sunflower seed and cake, cotton seed and cake, lablab seed, fishmeal) sources. This condition is inimical to acceptable supply of farm animal products like meat, milk, egg which are indispensable for body growth and development, and maintenance of physiological processes. Animal protein deficiency in the diet of the middling Nigerian is shown in the feeding of 3.24g per caput which is far beneath 35g daily obligation suggested by FAO (Hon *et al.,* 2009). The dietetic status of most Nigerians is categorized by insufficient protein consumption both in quality and quantity (Ojabo*et al.,* 2012). There is consequently, the need to rummage around for, recognize and develop substitute feed resources which are inexpensive and freely available (Oluremi*et al.,* 2010), to reduce the cost of production for viable development of farm animals so as to lessen the low per capita animal protein intake. The delinquent of animal protein scarcity in Nigeria and other developing nations has attained a terrible status which calls for urgent cure to avert the looming protein malnourishment (Ekenyem*et al.,* 2006). While, feeding accounts for about 70% of the entire cost of animal production specifically the non-ruminant, there is severe global worry about poor management of agricultural and native wastes which can be treated and transformed to useful feeding resources.

Over several eras, maize has not only served as a main food for humans and a chief raw material for most industries but, also a major source of energy in poultry diets, which makes it costly and sometimes inaccessible due to its seasonality. This situation has occasioned in amplified cost of feed production with an equivalent increase in the prices of poultry products. As a result, there is on-going intensive efforts by researchers to uncover unconventional energy sources that are cheaper and more readily available than maize. Unique of such probable substitutes is sweet orange (C*itrus sinensis*) peel meal that could serve as a cheaper energy source in poultry diets (Adeyemo and Borire 2002). It has been reported (Oluremi *et al.,* 2005) that sweet orange rind can be used as replacement feedstuff for maize in the ration of broiler at a level of 15%. Sweet orange (C*itrus sinensis*) fruit peel, remains one of the numerous agricultural wastes found in profusion in Nigeria, and with no cost involved, high in energy and not being harnessed for any productive use (Oluremi *et al.,* 2010). Rumen content is also an imperative animal by-product in the abattoir industry in Nigeria (Ahemen and Zahradden, 2010; Aneibo*et al.,* 2009) and can be improved into a helpful usage by taking advantage of its microbial population, rather than its present status as an agricultural waste. The use of most of these eccentric feedstuffs is restricted as a result of high fibre content, small nutrient content and the existence of anti-nutritional factors or toxic (Mc Donald *et al*., 1995). Conversely, diverse treatments such as drying, fermentation, soaking in water e.t.c have been reported to improve eccentric feedstuff and expand their nutritional profile (Oluremi *et al*., 2007b, Orayaga, 2010 and Oyewole, 2011). Its usage in the formulation of broiler diet as a replacement for maize, a highly economical conventional energy source will be of actual importance. The objective of this study is to determine the potential of bovine rumen liquor to improve the feed value of sweet orange peel in broiler feed.The aim of this present study is to determine the growth response of broiler chickens fed diets containing fermented sweet orange peel meal and production cost.

MATERIALS AND METHODS

3.1 Experimental Site

The study was conducted at the Poultry Unit of the Livestock Teaching and Research

Farm of the College of Animal Science, University of Agriculture Makurdi, Benue State. Makurdi is situated between latitude 7°44'N and longitude 8°21'E in the Guinea Savanna Zone of West Africa. The area has a yearly rainfall amid 6 - 8 months (May - October) and ranges from 508 to 1016 mm with a least temperature range of 24.20 ± 1.4°C and maximum temperature range of 36.33 ± 3.70°C. The relative humidity ranges between 39.50 ± 2.20% and 64.00 ± 4.80% (TAC, 2011).

3.2. Preparation of Test Ingredient and Experimental Diets

The test ingredient was Sweet orange (*Citrus sinensis*) peel (SOP) fermented with Rumen liquor for 72 hours. Sweet orange peel was collected fresh from orange fruit sellers within Makurdi metropolis a night before processing, by treating it with bovine rumen liquor. Fresh rumen content was collected from slaughtered cattle at the Wurukum abattoir in Makurdi and mixed to obtain a homogenous mass to which potable water was added in the ratio of 1kg: 1L. This mixture was stirred with a stirrer, sieved to collect rumen liquor (RL) which was added to sweet orange peel in ratio 1L :2.5kg and mixed thoroughly to obtain a homogenous mixture. The mixture was packed into polythene bags, tied at the open end, allowed to ferment for 72 hours and thereafter sun-dried on concrete platform to less than 10% moisture. The sun-dried fermented peels was milled to obtain a smaller size for the birds to eat, which was used to replace maize in a practical broiler diet at levels of 0%, 5%, 10%, 15% and 20% to obtain 5 different diets T1, T2, T3, T4 and T5, after mixing with other feed ingredients.

3.3. Experimental Animals, Design and Management

A hundred and fifty (150) day old broiler chicks was obtained from a reputable hatchery in Nigeria and used for the feeding trial. At day- old, the one hundred and fifty (150) broiler chicks were randomly grouped into five, and allocated to five (5) dietary treatments T1, T2, T3, T4 and T5. Each treatment was replicated 3 times with ten (10) birds per replicate at both starter (0-4 weeks) and finisher (5-8 weeks) phases. The replicates were randomly allocated to pens. The design of the feeding trial was a completely randomized design (CRD). The birds were raised in deep litter system. Feed and water were provided *ad libitum* for the 8-week feeding trial. Routine management practices which entails provision of feed, drinking water, washing of drinkers, cleaning of feeders and keeping the poultry house clean was followed. Anti-stress supplement was administered prior to and after each vaccination, and pre- and post-weekly weighing of the birds. Coccidiostat was administered at alternate weeks, and antibiotics given if and when necessary. Newcastle disease vaccine at day-old, infectious bursal disease vaccine at day 7, newcastle disease vaccine (Lasota) at day 14, infectious bursal vaccine at day 21 and newcastle disease vaccine at day 28 was given as recommended by the National Veterinary Research Institute, Vom Jos, Nigeria. Data was collected on growth performance, nutrient digestibility, carcass yield and blood profile.

Table 1: Composition of Broiler Starter Diets

	Experimental diets				
Ingredients (kg/100kg)	**T1(0%)**	**T2(5%)**	**T3(10%)**	**T4(15%)**	**T5(20%)**
Maize	54.4	51.68	48.96	46.24	43.52
Soybean meal	38.40	38.40	38.40	38.40	38.40
BSOP	0.00	2.72	5.44	8.16	10.88
Brewer’s dried grain	2.50	2.50	2.50	2.50	2.50
Fish meal	1.40	1.40	1.40	1.40	1.40
Bone meal	1.70	1.70	1.70	1.70	1.70
Limestone	1.00	1.00	1.00	1.00	1.00
Common salt	0.25	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25	0.25
DL-methionine	0.30	0.30	0.30	0.30	0.30
L-lysine	0.20	0.20	0.20	0.20	0.20
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated analysis					
ME (kcal/kg)	2889.78	2874.06	2858.34	2842.62	2826.89
Crude protein (%)	23.14	23.11	23.07	23.03	23.00
Crude fibre (%)	4.25	4.48	4.71	4.94	5.16
Ether extract	3.75	3.72	3.68	3.65	3.61
Lysine	1.44	1.43	1.42	1.42	1.41
Methionine	0.69	0.68	0.68	0.67	0.66
Calcium	1.13	1.13	1.13	1.13	1.13
Available phosphorus	0.72	0.71	0.71	0.70	0.69

T1= control diet, T2= 5% inclusion of sweet orange peel meal, T3= 10% inclusion of sweet orange peel meal
T4= 15% inclusion of sweet orange peel meal, T5= 20% inclusion of sweet orange peel meal
BSOP= Sweet Orange Peel Meal

Table 2: Composition of Finisher Broiler Diets

Ingredients (kg/100kg)	Experimental diets T1(0%)	T2(5%)	T3(10%)	T4(15%)	T5(20%)
Maize	57.00	54.15	51.30	48.45	45.60
Soybean meal	35.00	35.00	35.00	35.00	35.00
BSOP	0.00	2.85	5.70	8.55	11.40
Brewer's dried grain	2.50	2.50	2.50	2.50	2.50
Fish meal	0.50	0.50	0.50	0.50	0.50
Bone meal	1.80	1.80	1.80	1.80	1.80
Limestone	1.20	1.20	1.20	1.20	1.20
Palm oil	1.00	1.00	1.00	1.00	1.00
Common salt	0.25	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25	0.25
DL-methionine	0.30	0.30	0.30	0.30	0.30
L-lysine	0.20	0.20	0.20	0.20	0.20
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated analysis					
ME (kcal/kg)	2962.32	2945.84	2929.37	2912.90	2896.42
Crude protein (%)	21.49	21.45	21.41	21.37	21.34
Crude fibre (%)	4.11	4.35	4.59	4.83	5.07
Ether extract (%)	4.70	4.66	4.63	4.59	4.55
Lysine (%)	1.33	1.32	1.31	1.30	1.30
Methionine (%)	0.66	0.65	0.64	0.64	0.63
Calcium (%)	1.21	1.21	1.21	1.21	1.21
Available phosphorus	0.71	0.70	0.69	0.69	0.68

T1= control diet, T2= 5% inclusion of sweet orange peel meal, T3= 10% inclusion of sweet orange peel meal T4= 15% inclusion of sweet orange peel meal, T5= 20% inclusion of sweet orange peel meal, BSOP= Sweet Orange Peel Meal

3.4. Data Collection

The initial weight of all the birds were taken before being distributed into various dietary treatments. Records of weight gain by the experimental units were taken weekly by weighing birds in replicates at the end of each week. Body weight gain (BWG) was calculated by finding the difference between the weekly initial weight (Wi) and the final weight divided by the number of days (Wf)/7.

$$BWG = \frac{Wf - Wi}{7}$$

In a replicate, Overall average BWG per bird = $\frac{Wf-Wi}{7} x8x10.$

Records of feed intake was determined weekly (7 days) by calculating the difference between the quantity of feed given/supplied (Fs) and the quantity of feed remaining/residue (Fr).

Feed intake = $Fs - Fr / 7.$

In a replicate, the average feed intake per bird = $Fs - Fr / 7 \, x \, 8 \, x \, 10.$

Feed conversion ratio was calculated as ratio of feed consumed (g) to body weight gain (g)

$$\text{FCR} = \frac{\text{Feed intake (g)}}{\text{Body weight gain (g)}}$$

The protein intake per bird was calculated using the Crude protein (cp) of the diet and the feed intake.

$$\text{Protein Intake} = \frac{\text{Crude Protein} \times \text{Feed intake}}{100}$$

The protein Efficiency Ratio (PER) was calculated as ratio of daily weight gain (g) to Protein intake.

$$\text{PER} = \frac{\text{Daily weight gain}}{\text{Protein intake}}$$

Mortality (%) was calculated as ratio of Number of birds loss to number stocked multiplied by 100%

Digestibility trial

Digestibility trial to assess nutrient digestibility was carried out in the 8th week of the feeding trial. One bird per replicate was selected, moved into metabolic cages and allowed an adjustment period of three (3) days. The chickens were deprived of feed 12h before the commencing and termination of the digestibility trial to void the tract in other to certify that the first and last faecal droppings collected agree to the diets given. Daily feed intake and daily faecal output was collected once daily for 4 days at 8.00 am, weighed and dried in an oven at 105°C to constant weight. The oven-dried faecal droppings from each replicate was bulked, mixed and milled. Samples of the experimental diets and milled faecal droppings were analyzed for dry matter (DM), crude fibre (CF), ether extract (EE), ash and nitrogen free extract was also calculated (AOAC, 2000).

The coefficient of digestibility of nutrient was calculated using the formula:

Coefficient of digestibility $= \frac{\text{Nutrient in feed} - \text{nutrient in faeces}}{\text{nutrient in feed}}$

Cost/kg feed

The cost per kg of feed ingredients was calculated using the prevalent market prices of feedstuffs in ₦/kg. Total cost of feed consumed (₦/kg) per bird was resolute as total feed intake (kg) × cost per kg of feed. The cost of feed per weight gain (₦/kg) was calculated as total cost of feed consumed/total body weight gain. Cost saving due to SOPM was calculated by deducting total cost of production of each treatment from the total cost of production of broiler chicken fed control diet. Operational cost per bird was calculated by totaling all other expendituresexcludingcosts on feed and day old chicks. Total cost of production was calculated by adding cost of day old chick, feed cost per chick andoperational cost.

Feed cost of producing a bird = Total feed consumed/bird (kg) × Unit cost of feed

Chemical Analysis

The sample of the fermented sweet orange peel meal and faeces was analyzed for their proximate composition using the standard methods (AOAC, 2000).

Statistical Analysis

Data was subjected to analysis of Variance (ANOVA) using SAS (2008) software package and the means were separated using Duncan's Multiple Range Test (DMRT). All statements of significance was based on the 0.05 level of probability.

Statistical Model

$Y_{ij} = \mu + T_i + \varepsilon_{ij}$

Y_{ij}= Individual Observation

μ = Overall mean

T_i= Effect of fermented sweet orange peel meal (i^{th} treatment)

ε_{ij}= Experimental error containing all uncontrolled sources of variation

RESULTS

Table 3: Proximate Composition of the Biodegraded Sweet Orange Peel (SOP)

Components	% Dry matter
Dry matter	90.50
Crude protein	8.45
Crude fibre	11.85
Either extract	9.05
Ash	8.40
Nitrogen Free Extract	62.25
Energy (Kcal/KgME)	3224.45

ME =Metabolisable energy (Kcal/kg) = 37 × % CP +81% × % EE +35 × %NFE (Pauzenga, 1985)

Proximate Composition of the Biodegraded Sweet Orange Peel (SOP)

The proximate composition of the bovine filtrate fermented sweet orange peels used in the study is presented in the table above. The outcome showed that it contained 90.50% dry matter, 8.45% crude protein, 11.85% crude fibre, 9.05% ether extracts, 8.40% ash and 62.25% Nitrogen Free Extract (NFE). The nutrient value of feed ingredient is one of the major requirement for making of good quality feeds. The rudimentary nutrients that cannot be negotiated in the choice of ingredients for feed formulation are protein and energy Akpe*et al.* (2019). The crude protein value obtained in this work is greater than 7.40% reported by Ojabo*et al.* (2014) who reported on sundried sweet orange peel meal, 8.05% reported by Otu*et al*. (2021) who also worked on sundried sweet orange meal. The variance in crude protein composition could be attributed to the processing method of the trial diet. The crude Fibre 11.85% establish in this study was lesser than 13.30% reported by Sunmola*et al.* (2019), who worked on sundried sweet orange peel meal and 12.76% reported by Akpe*et al.* (2019), who worked on Fermented sweet orange peels with rumen content for 48 hours. This decline could be ascribed to progressive Fermentation period. The ash 8.40% obtained in this study was greater than 4.47% reported by Ani *et al.,* (2012) who used Raw bambaranut waste to feed broilers but analogous to 8.19% reported by Ojabo*et al.* (2014) who worked on sundried sweet orange peel meal and 7. 50% Akpe*et al*. (2019) who used rumen content to Ferment sweet orange peels for 48 hours. The high ash content might be accredited to the longer period of Fermentation and the specie of orange used. The ether extract obtained in this study 9.05% is advanced than 2.70% reported by Akpe*et al*. (2019) and 3.22% reported by Oluwabiyi*et al.* (2020) who worked on sweet orange peels preserved with ruminal content for 48 hours. The Nitrogen free extract gotten from this study (62.25%) is comparable to 61.78% reported by Akpe*et al*. (2019). The metabolisable energy found in this study (3224.45kcal/kg) is more than 2648.82kcal/kg as reported by Akpe*et al*. (2019) The high energy rate of biodegraded SOP in this study is in agreement with the findings of Iyayi and Aderolu (2004) who stated that biodegraded agro-by-products rise energy value but equivalent to 3432. 32kcal/kg maize by Aduku (2005). This effectrevealed that sweet orange rinds have relative energy level with maize when fermented with bovine filtrate for 72 hours

Table 4: Effect of Experimental Diets on the Performance of Starter Broiler Chicks

Parameters	Experimental Diets					
	T1(0%)	**T2(5%)**	**T3(10%)**	**T4(15%)**	**T5(20%)**	**SEM**
Initial weight (g)	46.05	47.45	46.23	47.26	45.53	0.51^{ns}
Final weight (g)	480.00^{a}	438.15^{ab}	428.67^{ab}	406.06^{b}	336.67^{c}	14.23^{*}
Feed intake (g)	30.89^{a}	29.36^{a}	28.26^{a}	27.40^{a}	20.48^{b}	1.04^{*}
Daily weight gain (g)	15.50^{a}	13.94^{ab}	13.66^{ab}	12.81^{b}	10.40^{c}	0.50^{*}
Feed conversion ratio	1.99	2.11	2.07	2.14	1.99	0.03^{ns}
Protein intake (g)	7.15^{a}	6.79^{a}	6.54^{a}	6.34^{a}	4.74^{b}	0.24^{*}
Protein efficiency ratio	2.17	2.06	2.09	2.02	2.18	0.03^{ns}
Mortality (%)	0.33	0.33	0.33	1.00	1.00	0.19^{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,
T1 = 0% maize replacement with biodegraded sweet orange peel (Control diet)
T2 = 5% maize replacement with biodegraded sweet orange peel
T3 = 10% maize replacement with biodegraded sweet orange peel
T4 = 15% maize replacement with biodegraded sweet orange peel
T5 = 20% maize replacement with biodegraded sweet orange peel

Table 5: Effect of Experimental Diets on the Performance of Finisher Broiler Chickens

Parameters	Experimental Diets					
	T1(0%)	T2(5%)	T3(10%)	T4(15%)	T5(20%)	**SEM**
Initial weight (g)	46.05	47.45	46.23	47.26	45.53	0.51^{ns}
Final weight (g)	1410.13^{a}	1491.33^{a}	1395.67^{a}	1303.09^{a}	1120.77^{b}	42.88^{*}
Feed intake (g)	52.93^{b}	56.17^{a}	55.85^{a}	55.61^{a}	50.67^{c}	0.75^{*}
Daily weight gain (g)	24.36^{ab}	25.81^{a}	25.21^{a}	23.70^{ab}	19.20^{b}	0.95^{*}
FCR	2.17	2.18	2.22	2.35	2.64	0.08^{ns}
Protein intake (g)	11.37^{c}	12.07^{a}	12.02^{a}	11.95^{b}	11.89^{b}	0.16^{*}
PER	2.14^{a}	2.14^{a}	2.15^{a}	1.98^{b}	1.76^{b}	0.07^{*}
Mortality (%)	0.33	0.60	0.37	0.33	0.33	0.18^{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,
T1 = 0% maize replacement with biodegraded sweet orange peel meal (Control diet)
T2 = 5% maize replacement with biodegraded sweet orange peel meal
T3 = 10% maize replacement with biodegraded sweet orange peel meal
T4 = 15% maize replacement with biodegraded sweet orange peel meal
T5 = 20% maize replacement with biodegraded sweet orange peel meal

Growth Performance of Broiler Chicks fed graded level of 72 hours filtrate-fermented sweet orange peel based diet at Starter Phase

Table 4 above displays the growth performance of four (4) weeks old broiler chicken fed graded level of 72 hours filtrate-fermented sweet orange peel based diet. There were significant differences (p<0.05) in Final weight, Feed intake, Daily weight gain and Protein intake. The significantly (p<0.05) maximum body weight (480.00g) was observed in the control group T1 (480.00g) tailed by broilers in T2 (438.15g), T3(428.67g) and T4(406.06g) which were comparable to the control while T5 was least. There was a firmdecline in the facts of the abovementioned parameters as the level of BSOP addition augmented from 5%, 10%, 15% and 20%. The average feed intake of the birds were significantly different (p<0.05) across the treatments. The lowest feed intake was noted for the broilers of group T5 (20.48g) and highest was consumed by group T1 (30.89g). Amid the birds fed BSOP, those fed 5% (T2) of the test ingredient performed better in final body weight (438.15g) than those placed on 10% (428.67g), 15% (406.06g) and 20% (336.67g).

Daily weight gain and Protein intake were significantly (p<0.05) different through the treatment and this followed the same trend as final weight gain. The values of daily weight gain for birds in group T2 (13.94g) and T3 (13.66g) were statistically comparable with the value for the birds in the control group (T1), 15.50g. The protein intake of the birds across the treatment were significantly different ($p<0.05$). The birds on trial diet were detected to have a diminished value in protein intake with growing level of the test ingredient (BSOP). Nevertheless, birds in T2 (6.79g), T3 (6.54g) and T4 (6.34g) had comparable values with the birds on control diet T1 (7.15g). The protein efficiency ratio (PER) in this study did not differ significantly ($p>0.05$) between the treatment groups and this denotes that the addition of BSOP in the diet did not affect the utilization and absorption of protein in the diets. The PER found in this study was higher than 1.46 to 1.58 reported by Amaga (2009), the alteration could be attributed to the processing method of the test ingredient (SOP). Mortality values were not significantly ($p>0.05$) different among the birds and this infers that BSOP is not deadly to the health of the birds.Final body weight dropped across the treatment with the addition of the test ingredient. This agreed with the discoveries of Agu*et al*. (2010) who reported a significantly ($P<0.0$) lower value in final body weight of the broiler chickens fed diets comprising SOPM. The result also conformed to that of Ani *et al.* (2015) who reported that growing levels of processed SOPM from 5 % to 20 % significantly declined the average final body weight and weight gain related with the birds fed control diet. This could be owing to lower feed intake by the birds. Feed intake declined significantly across the treatments as a result of the inclusion of bovine filtrate Fermented sweet orange peel meal at variable levels. The product of this study also agreed with the discoveries of Abbas *et al*. (2013) on substantial reduction in feed intake of broiler chickens at all inclusion levels of dietary SOPM. This result agrees with Agu*et al.* (2010) and Oluremi*et al*. (2007) who reported on sun-dried sweet orange peel meal. The decreased feed intake at various levels notwithstanding Fermentation of test material could be suggestive of high concentration of anti-nutritional features which are existing in orange peels as they are known to reduce palatability and reduce digestibility of livestock feed (Makkar, 2003). The feed conversion ratio wasn't affected meaningfully across the treatment despite the varying level of Sweet orange peels inclusion in the diet. The feed conversion ratio acquired in this study falls within the range of 2 to 5 as recommended by Oluyemi and Robert (2000), as normal for broiler chicken but the feed intake and daily body weight were affected. The values of daily weight gain and feed intake obtained for finisher broiler chicks falls within the expected minimum value of 19g and 37g respectively, reported by Aduku (2005). The weight gain of the birds dropped across the treatment with higher inclusion of the test ingredients and this findings agree with Ani *et al*. (2011) who reported that feeding of diets containing anti-nutrients by poultry birds can result into decline weight gain of birds as a result of lower feed intake and lower effectiveness of feed utilization. The high crude fibre level enclosed in the orange peel can precipitate negative effects on broiler performance (Ayed*et al.,* 2011; Soltani*et al*., 2012). Protein Efficiency Ratio and protein intake were observed to have deteriorated across the treatment and this result disagree with Oluwabiyi*et al.* (2020) who reported on biodegradable sweet orange peel meal utilization in Rabbit feed. This result may be owed to the failure of the birds to handle high dietary Fibreportion in the feed. The PER achieved in this study was higher than 1.46 to 1.58 reported by Amaga (2009), the variance could be attributed to the processing method of the test ingredient (SOP). Similar observation was also reported by Abbas *et al*. (2013) on broiler chicks fed sweet orange peel based diet. Mortality values were not significantly ($p>0.05$) different among the birds and this implies that BSOP is not fatal to the health of the birds. Mortality recorded could not be linked to feed poison since past information on sweet orange peel meal have recorded zero mortality even at higher percentages of maize replacement Oluremi*et a*l. (2008).

Growth Performance of Broiler Chicks fed graded level of 72 hours filtrate-fermented sweet orange peel based diet at Finisher Phase

Table 5above indicate the result of growth performance of finisher broiler fed graded level of 72 hours filtrate-fermented sweet orange peel based diet. There were significant difference ($p<0.05$) in the average final weight, feed intake and daily weight gain of birds. The maximum value in final weight of the birds was seen in T2 (1491.33g) and the lowest value was recorded in group T5 (1120.77g). Though, the birds in T1 (1410.13g), T2 (1491.33g), and T3 (1395.67g) are statistically similar. This denotes that the performances of finisher broiler in the control group (T1) was not superior to the performance of the finisher broiler in the SOP based diets.

Feed intake varies significantly ($p<0.05$) among the dietary treatment with birds in the 5% BSOP inclusion recording the highest feed intake (56.17g). The values across the treatment had no peculiar variation, however, it was observed that birds on the experimental diets T2 (56.17g), T4 (55.61g) and T5 (50.67g) statistically had comparable values with birds in the control group T1 (52.93g). Though, the birds in T2 (56.17g) had the highest value and the birds in T5 (50.67g) had the lowest value for feed intake. Daily weight gain was significantly ($p<0.05$) affected across the treatment and this study display that birds in group T2 (25.81g) performed better in weight gain even further than the birds in the control group (24.36g). Feed Conversion Ratio (FCR) was not significantly different ($p>0.05$) among the treatments. This implies that the test ingredients had no effect on the conversion ratio of the birds. Protein intake vary significantly ($p<0.05$) among the treatments, however, birds on the experimental diet T2 (12.07g) had highest values of protein intake likened to the birds on control diet T1 (11.37g). Protein efficiency ratio also vary significantly ($p<0.05$) among the treatments with the birds in group T2 (2.14), T3 (2.15) and T4 (1.98) statistically similar with the birds in the control group T1 (2.14).

Table 6. Effect of Experimental Diet on Digestibility trials Of Broiler Chickens

	Experimental diets					
Parameters	**T1(0%)**	**T2(5%)**	**T3(10%)**	**T4(15%)**	**T5(20%)**	**SEM**
Dry matter	80.23^{a}	79.25^{ab}	77.01^{ab}	75.09^{ab}	72.45^{b}	0.91*
Crude protein	78.05^{a}	74.25^{ab}	71.73^{b}	70.12^{b}	69.17^{b}	1.02*
Crude fibre	77.48^{a}	75.94^{ab}	73.58^{ab}	69.27^{b}	67.01^{b}	0.70*
Ether extract	73.61^{a}	70.92^{b}	70.06^{b}	69.53^{b}	69.28^{b}	0.51*
NFE	75.59^{a}	71.68^{b}	70.01^{b}	69.56^{b}	69.04^{b}	1.04*
Energy	80.65^{a}	77.32^{ab}	74.29^{b}	70.87^{b}	69.12^{b}	1.85*

NFE= Nitrogen free extract T1 = 0% maize replacement with biodegraded sweet orange peel (Control diet), T2 = 5% maize replacement with biodegraded sweet orange peel, T3 = 10% maize replacement with biodegraded sweet orange peel, T4 = 15% maize replacement with biodegraded sweet orange peel, T5 = 20% maize replacement with biodegraded sweet orange peel

Digestibility Trial

The result of experimental diet on digestibility trials of broiler chickens is presented in table 6 above.The digestibility parameters which comprise of dry matter, Crude protein, Crude Fibre, ether extract, Nitrogen free extract and Energy were significantly affected (p<0.05) among treatment means. It was detected from table 6 above that the digestibility values for each nutrients ranges within 60-80%. The broiler chickens in the control group (T1) showed a little higher value related to the other chickens in the sweet orange peel based dietary treatments. Two essentialfactors modifying feed quality are crude protein and Fibre. The coefficient of crude protein digestibility in the maize-based diet group (T1) was higher (78.05%) but statistically similar to T2 (74.25%) while T3 (71.73%) and T4 (70.12%) were statistically similar with T5 (69.17%) having the least value. This possibly will be the consequence of binding with protein by some anti-nutrients like saponin and tannin existing in the sweet orange peel as reported by Oluremi*et al.* (2007), though the processing method has reduced their concentration a little. The crude Fibre were significantly affected diagonallyin the treatment with T1 (77.48%) having the highest value but statistically similar to T2 (75.94%) and T3 (73.58%). The broiler chickens fall in nutrient absorption with higher inclusion of the sweet orange peels due to its high Fibre content. Fibrehave a tendency to limit the amount of intake and the retention of the available energy by birds, and contributes to too much nutrient excretion (Kung and Grueling, 2000).

Table 7: Effect of Experimental Diets on the Cost of Production of Broiler Chicken

Parameters	**Experimental Diets**					
	T1(0%)	**T2(5%)**	**T3(10%)**	**T4(15%)**	**T5(20%)**	**SEM**
Cost of day old chick (₦/chick)	180	180	180	180	180	_
Starter feed cost (₦/kg)	135.30	131.90	128.50	125.10	121.70	1.29
Cost of saving by BSOP(₦/kg)	-	3.40	6.80	10.20	13.60	1.29
Finisher feed cost (#/kg)	131.87	128.31	124.75	121.18	117.62	1.35
Cost of saving by BSOP(₦/kg)	-	3.56	7.12	10.69	14.25	1.35
Feed cost ₦/kg weight gain	292.12	283.64	280.70	274.58	265.24	4.96
Feed cost / bird (₦)	201.80^{a}	195.43^{a}	198.59^{a}	155.27^{b}	183.14^{a}	5.80*
Operational Cost (₦)	103.33	103.33	103.33	103.33	103.33	-
Total cost of production(₦/bird)	415.80^{a}	413.55^{a}	370.28^{ab}	330.33^{b}	379.85^{ab}	11.54*

$^{a, b}$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, BSOP= Biodegraded Sweet Orange Peel
T1 = 0% maize replacement with biodegraded sweet orange peel (Control diet)
T2 = 5% maize replacement with biodegraded sweet orange peel
T3 = 10% maize replacement with biodegraded sweet orange peel
T4 = 15% maize replacement with biodegraded sweet orange peel,
T5 = 20% maize replacement with biodegraded sweet orange peel

COST - BENEFITS ANALYSIS

The cost benefits indicators of broiler chickens Fed graded level of 72 hours filtrate- fermented sweet orange peel based diet is presented in table 7above. The result indicated that the cost benefits parameters starter feed cost (₦/kg), percentage cost of saving by BSOP at starter diet, finisher feed cost (₦/kg), percentage cost of saving by BSOP at finisher diet and feed cost ₦/kg weight gain were significantly not affected ($p>0.05$). T1(135.30₦/kg) Starter feed cost recorded the highest value and statistically similar to T2 (131.90₦/kg) while T3 (128.50₦/kg), T4 (125.10₦/kg) and T5 (121.70₦/kg) are statistically similar. Percentage cost of saving by BSOP at starter diet improved with the higher inclusion of BSOP, T5 (13.60%) recorded the highest value tailed by T4 (10.20%), T3 (6.80%) and T2 (3.40%). Finisher feed cost of T1 (131.87₦/kg) recorded the highest value, T2 (128.31₦/kg), T3 (124.75₦/kg), T4 (121.18₦/kg) were statistically similar while T5 (117.62₦/kg) recorded the least. Percentage cost of saving by BSOP at finisher diet increased with more inclusion of BSOP, T5 (14.25%) recorded the highest value followed by T4 (10.69%), T3 (7.12%) and T2 (3.56%). Feed cost per kilogram weight gain recorded the maximum value for T1 (292.12₦/kg) and statistically similar to T2 (283.64₦/kg), T3 (280.70₦/kg), T4 (274.58₦/kg) and T5 (265.24₦/kg). Though, feed cost/bird(₦) were significantly affected ($p<0.05$) through the treatment. T1 (201.80₦) recorded the highest value, T2 (195.43₦), T3 (198.59₦), T5 (183.14₦) were statistically similar and T4 (155.27₦) recorded the least. Total cost of production were significantly different ($p<0.05$) as well. T1 (415.80₦) recorded the highest value and statistically alike with T2 (413.55₦) while T3 (370.28₦),T4 (330.33₦) and T5 (379.85₦) were statistically similar.

The result for cost of production of finisher broiler fed graded level of 72 hours filtrate-fermented sweet orange peel based diet indicated that 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 transpired for feed cost of raising a chick from day-old to 56^{th} day. The cost of day-old chicks as percentage of total cost of production was significantly ($p<0.05$) affected by the diets. As the BSOP/maize replacement levels increased, the feed cost per weight gain increasingly decreased amid the treatments. The progressive decreased is in line with the report of Ani *et al.* (2012); Ojabo*et al.* (2014); Ngiki*et al.* (2014) and Olaifa*et al.* (2015) who reported that the feed cost per weight gain lessened with increased dietary levels of Bambara nut, sweet orange peel, cassava root-leaf meal mixture and cassava peel meal based diet correspondingly on broiler chickens. Cost savings due to sweet orange peel improved with increased levels of sweet orange peel as a replacement for maize (conventional feed). The feed cost per bird was significantly ($p<0.05$) affected by the diet suggestively due to less feed consumed by the birds. The total cost of production were significantly ($p<0.05$) affected across the treatments with a progressively reduced value as the BSOP/maize replacement levels increased. This could be due to minimal cost inference of moving round to get orange peels from the sellers and getting rumen content from slaughter house to make the test ingredients (SOP) for the replacement of maize.

CONCLUSION

The chemical composition of fermented SOP treated with rumen filtrate for 72 hours revealed that it has a crude protein of 8.45% making it comparable to maize in feedstuff for poultry.

The result obtained has shown that feeding birds at 5% maize replacement with SOP gave the highest growth performance than the birds in the other dietary levels although statistically similar. However, the progressive inclusion of the test ingredient

(SOP) had adverse effect on the growth performance of broiler chicken.

Birds fed fermented SOP treated with rumen filtrate for 72 hours was significantly ($p<0.05$) affected in PCV, WBC and MCV among the treatments. Feeding of this test ingredient (SOP) brings about a reduction in the glucose level of the birds and significantly ($p<0.05$) affect the Albumin level.

There was a slight variation in the carcass of the birds with the birds in the control group having the highest dressed weight and dressing percent. Therefore, the inclusion of SOP had adverse effect on the carcass of the birds.

Although, there was a reduction in the total cost of production of the birds and the feed cost per bird as the level of SOP increase however with no peculiar pattern of variation.

RECOMMENDATION

It is recommended that rumen filtrate-treated sweet orange fruit peels fermented for longer duration beyond 72 hours be evaluated for their effect on the growth response of broiler chickens. Farmers can include rumen filtrate-treated sweet orange peels up to 5% in the diets of their broilers for improved growth performance. Further research is needed to assess the effects of SOP to improve its suitability as a feed resource and growth promoter in poultry production.

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