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GROWTH PERFORMANCE, NUTRIENT DIGESTIBILITY AND HAEMATOLOGICAL INDICES OF BROILER CHICKENS FED DIETS CONTAINING BIODEGRADED SWEET ORANGE (CITRUS SINENSIS) PEEL MEAL AS REPLACEMENT FOR MAIZE

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ABSTRACT
A 56-days feeding trial was conducted to determine the effect of using the biodegradation sweet orange peel meal (BSOPM) as a replacement of maize in diet on growth performance, nutrient digestibility and haematological parameters of broiler chicks. A total of 180, one-day old broilers were distributed equally into six dietary treatments with 3 replicate of 10 chicks in each in a completely randomized design. The biodegraded sweet orange peel meal (BSOPM) was used to replaced maize at 0, 5, 10, 15, 20, and 25% of the control diet (T0) and five test diets (T5) (T10) (T5) (T20) and (T25) in finishers broilers diets. Laboratory analyses were carried out on the BSOMP and experimental diets to determine its proximate composition and the result revealed that, BSOPM contained metabolizable energy content of 2854.24 kcal/kg and 89.60% dry matter (DM), 7.58% crude protein (CP), 11.11 % crude fibre (CF), 2.89% ether extract (EE), 11.58% total ash (TA), 66.84% nitrogen free extract (NFE). Results also showed that average final live body weight ranged from 798.68 – 1582.64g. Average daily feed intake and feed conversion ratio were significantly ($p<0.05$) affected across the dietary treatments while final weight gain, average daily weight gain and mortality were not significantly ($p>0.05$) affected across the dietary treatments. The results of haematological and serum biochemical indices showed that, there were no significant differences ($p>0.05$) except for mean corpuscular volume (MCV) indicating that no physiological abnormalities resulted from the feeding of BSOPM to broiler chicken.

Keywords: Chicken farming, broiler farming, chickens fed and chicken growth.

1. INTRODUCTION
The high cost of meat and meat products in the country is due to the high cost of feed inputs. Reddy, (2013) reported that feed accounts for 65-70% of the total cost in the intensive system of animal production. The situation is the result of competition between man and livestock for some feed and food ingredients, particularly energy sources. This competition is more rigorous in developing countries thereby causing the developing countries to import cereals and other feed sources to meet the needs of both humans and animals. Animal nutritionists are therefore in the search for alternative energy sources for use in livestock feed compounding such as residues of crop harvests and agro-by-products (mango fruits reject, citrus by-products, maize offal, molasses, rice bran) be used partially or totally to replace maize in livestock diets, to reduce cost

and enhance cheaper meat production and therefore make available the major food items for human consumption.
The potential of citrus by-products has been reported by several researchers. Oluremi *et al.*, (2006) reported on the products and by-products of citrus fruits. According to these authors, whole peel or rind (pericarp) consists of flavedo, the exterior yellow peels (Epicarp) and albedo the interior white spongy peel (Mesocarp) which (Albedo) is rich in pectin. Sweet orange rind has been observed to be a source of calorie and protein comparable with maize (Oluremi *et al.*, (2008). The whole peels combined with the pulp residue (rag) and molasses can become a feed for animals. Pulp which is principally edible portion (endocarp) is usually combined with other residues to produce by-products used in animal nutrition. In this study, attempt was made to assess the replacement value of biodegraded sweet orange peels for maize in the diet of broiler chicken.

2.MATERIALS AND METHODS

2.1 Experimental Site

The study was conducted at the Poultry Unit of the Livestock Teaching and Research Farm, Joseph Sarwuan Tarka University Makurdi, Benue State. Makurdi lies within the Guinea Savannah region of Nigeria.

2.2 Sources and Preparation of the Test Ingredient

Fresh sweet orange (*Citrus sinensis*) peels were collected from peeled orange fruit sellers within Makurdi metropolis a night before the early morning when rumen liquor was collected for its treatment. Rumen content liquor was obtained from the Wurukum abattoir in Makurdi and mixed with drinking water at a ratio of 1Kg:1 Liter and thereafter filterated to obtain a filtrate called rumen filtrate (RF) which was added to sweet orange peel (SOP) at ratio 1L:5Kg respectively and mixed. The mixture was poured into a polythene bag, tied at the open end, kept in a shade and allowed to ferment for 48 hours to obtain biodegraded sweet orange peel which was sun dried to less than 10% moisture. The dried material was milled to obtained biodegradable sweet orange peel meal (BSOPM).

2.3 Laboratory Analysis

2.3.1 Proximate analysis

The milled sample of biodegradable sweet orange fruit peel meal and experimental diets were analysed for their proximate constituents using standard procedures AOAC, (2000).

2.3.2 Experimental diets

The sundried biodegraded sweet orange peel was milled and used to prepare six experimental diets T_0, T_5, T_{10}, T_{15}, T_{20} and T_{25} in which dietary maize were replaced with 0, 5, 10, 15, 20 and 25% of biodegraded sweet orange peel meal in broiler diets as presented in Table 1 to meet or exceed the nutrients requirement of broiler chickens as recommended by Olomu, (2000).

2.3.3 Experimental animal, design and management

A total of one hundred and eighty (180) day old broiler chicks was purchased from NAS Tech Hatchery, Ibadan, Nigeria. The birds were grouped into six (6) dietary treatment groups on equal

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numbers and comparable weight basis in a completely randomized design (CRD). Each group had three (3) replicates of ten (10) chicks per replication. The birds were raised on deep litter system and routine medication and Vaccination schedule were strictly adhered to. The birds were fed *ad-libitum* for eight weeks (56days) and data collected on growth performance, nutrient digestibility and blood profile.

2.3.4 Data collection

Data were collected on growth performance, nutrient digestibility and haematological

2.3.5 Growth performance

Growth performance parameters measured included body weight, weight gain, feed intake and feed conversion ratio (FCR).

Table 1. Ingredient Composition of Experimental Diets for Broiler Starter (1-4 weeks) Experimental Diets

Parameters	**T_0**	**T_5**	**T_{10}**	**T_{15}**	**T_{20}**	**T_{25}**
Maize	53.50	50.82	48.15	45.47	42.80	40.12
BSOPM	-	2.68	5.35	8.03	10.70	13.38
Soybeans meal	34.00	34.00	34.00	34.00	34.00	34.00
Brewer dried grain (BDG)	4.00	4.00	4.00	4.00	4.00	4.00
Blood meal	3.00	3.00	3.00	3.00	3.00	3.00
Palm oil	1.50	1.50	1.50	1.50	1.50	1.50
Bone ash	2.00	2.00	2.00	2.00	2.00	2.00
Limestone	1.00	1.00	1.00	1.00	1.00	1.00
Lysine	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25
Vit/min. 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	100.0	100.0	100.0	100.0	100.0	100.0
Calculated analysis						
ME	2953.87	2938.44	2922.96	2907.53	2892.05	2876.62

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(kcal/kg)						
Crude protein (%)	23.16	23.12	23.09	23.05	23.02	22.98
Crude fibre (%)	4.17	4.39	4.62	4.84	5.07	5.29
Ether extract (%)	3.78	3.75	3.72	3.69	3.66	3.63
Lysine	1.52	1.51	1.51	1.50	1.49	1.49
Methionine (%)	0.74	0.73	0.73	0.72	0.72	0.71
Calcium (%)	1.30	1.30	1.30	1.30	1.29	1.29
Phosphorus (%)	0.70	0.69	0.69	0.68	0.67	0.66

Metabolizable Energy (ME) = calculated according to the formula of Pauzenga (1985) while NFE was also calculated as described by Association of Official Analytical Chemists (AOAC, 2006), ME= 37×%CP+81.8×%EE+35.6×%NFE while %NFE = %DM – (%CP + %CF + %EE + %Ash). ME and %NFE as referenced by Etuk *et al.*, (2012) and Igwebuike *et al.*, [16]; Shaahu *et al.*, (2014); Madziga *et al.*, (2017).

BSOPM = Sweet orange fruit peel meal, Vit. /Min = vitamin and mineral, ME = Metabolizable energy, BDG = Brewer's dried grain

T_0= Control diet containing 0%BSOPM

T_5= Diet containing 5%BSOPM

T_{10}= Diet containing 10%BSOPM

T_{15} = Diet containing 15%BSOPM

T_{20} = Diet containing 20%BSOPM

T_{25} Diet containing 25%BSOPM

Table 2. Ingredients Composition (%) of Experimental Diets for Broiler Finisher (5-8 weeks) Experimental Diets

Parameters	T_0	T_5	T_{10}	T_{15}	T_{20}	T_{25}
Maize	56.50	53.67	50.85	48.02	45.20	42.37
BSOPM	-	2.83	5.65	8.48	11.30	14.13
Soybeans meal	30.00	30.00	30.00	30.00	30.00	30.00
BDG	4.00	4.00	4.00	4.00	4.00	4.00
Blood meal	3.00	3.00	3.00	3.00	3.00	3.00
Palm oil	2.40	2.40	2.40	2.40	2.40	2.40
Bone ash	2.00	2.00	2.00	2.00	2.00	2.00
Limestone	1.05	1.05	1.05	1.05	1.05	1.05
Lysine	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.30	0.30	0.30	0.30	0.30	0.30
Vit/min. 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
Calculated analysis						
ME (kcal/kg)	3040.03	3023.14	3007.39	2991.09	2974.74	2958.45
Crude protein (%)	21.66	21.62	21.59	21.55	21.52	21.48
Crude fibre (%)	3.99	4.22	4.46	4.70	4.94	5.18
Ether extract (%)	3.74	3.71	3.68	3.65	3.62	3.59
Lysine (%)	1.42	1.41	1.40	1.39	1.39	1.38
Methionine (%)	0.71	0.70	0.70	0.69	0.68	0.68
Calcium (%)	1.29	1.29	1.28	1.29	1.29	1.29
Phosphorus (%)	0.69	0.68	0.67	0.66	0.65	0.64

Metabolizable Energy (ME) = calculated according to the formula of Pauzenga (1985) while NFE was also calculated as described by Association of Official Analytical Chemists (AOAC, 2006), ME= 37×%CP+81.8×%EE+35.6×%NFE while %NFE = %DM – (%CP + %CF + %EE + %Ash). ME and %NFE as referenced by Etuk *et al.*, (2012) and Igwebuike *et al.*, (2013); Shaahu *et al.*, (2014); Madziga *et al.*, (2017).

Vit. /Min = vitamin and mineral and BDG = Brewer's dried grain

BSOPM = Sweet orange fruit peel meal

ME = Metabolizable energy,

T_0= Control diet containing 0%BSOPM

T_5= Diet containing 5%BSOPM

T_{10}= Diet containing 10%BSOPM

T_{15} = Diet containing 15%BSOPM

T_{20} = Diet containing 20%BSOPM

T_{25} = Diet containing 25%BSOPM

a. Body weight of broiler chickens

The initial and final weight of the broiler birds were taken at the start and end of the trial using a top load sensitive weighing scale on treatment replicate basis.

b. Body weight gain

The total weight gain was calculated as the difference between the final and initial weight while daily weight gain was calculated as the total weight gain divided by the number of days (63) of the experimental period.

c. Feed intake

Feed intake was determined by difference using the initial weight of feed served per each replicate and weight of the left over feed at the end of the week. Total feed intake was calculated as the sum of weekly feed intake of the experimental period.

d. Feed conversion ratio

The feed consumed and the body weight gained by the broiler in each replicate was used to compute the feed conversion ratio (FCR) using the following formula:

$$FCR = \frac{feed\ consumed\ (g)}{weight\ gained\ (g)}$$

2.3.6 Digestibility trial

Metabolic study was conducted during the last week of the feeding trial to determine dietary nutrient utilization by the broiler chickens. One (1) live broiler chicken per each treatment replicate approximating their replicate live weight was selected, moved into metabolic cages and allowed an adjustment period of three (3) days for the digestibility trial. Thereafter, the birds were served daily weighed diets for four (4) days in which the birds were fed eighty percent (80%) of their daily feed intake per day since the level of feed intake increases the rate of passage of digesta from the gastro-intestinal tract (GIT) and thus, reducing digestibility of nutrients (Lang, 1981). Left over feed was collected and weighed to determine feed intake by difference. Wet fecal dropping per replicate was collected daily, weighed, oven-dried at 105 ^oC for twenty-four (24) hours and reweighed. Fecal samples per replicate were bulked, milled and stored in airtight sample bottles and a homogenous sample from each dietary replicate was fetched and analyzed for their nutrient composition using the procedure of AOAC (2005) for its proximate nutrient contents. The fecal samples were analyzed for dry matter (DM), crude protein

(CP), crude fiber (CF), ether extract (EE) and ash at the Animal Nutrition Laboratory of the Department of Animal Sciences, Joseph Sarwuan Tarka University (Formerly, University of Agriculture), Makurdi. Nitrogen free extract (NFE) was also calculated as:

%NFE = 100 – (%CP + %CF + %EE + %Ash) + %moisture. ……………………………………………………………………(i)

The quantity of nutrients in diet and fecal were determined by multiplying nutrient percentage in diet and fecal by dry matter in diet respectively. Nutrient retained was determined as nutrient intake less nutrient voided in feces.

$$D = \frac{1-F}{1} * 100\% \quad \text{……(ii)}$$

Where;
D = digestibility coefficient
I = nutrient intake and
F = nutrient voided in faeces

2.3.7 Haematological parameters

At the end of the feeding trial, three (3) birds per treatment at the rate of one (1) of similar live body weight per each replicate were selected for the evaluation of the haematological and serum biochemical indices. The birds were fasted for 12 hours and bled by slaughtering at the neck region. Immediately after slaughtering, 3ml blood for haematological assay was collected from each chicken into sample bottle containing 3mg of dipotassium salts of ethylene diamine tetraacetic acid (EDTA-K2). The haematological indices as packed cell volume (PCV), red blood cell count (RBC), white blood cell count (WBC), haemoglobin (Hb), mean corpuscular hemoglobin concentration (MCHC), mean corpuscular hemoglobin (MCH) and mean corpuscular volume (MCV).) were determined according to Jain (1986) and Kelly (1979). The distribution of various white blood cells as Heterophil, basophil, monocytes, lymphocytes and eosinophil was done by shilling method for differential leucocyte count (Mitruka and Rawnsley, 1977).

2.4 Data Analysis

Data collected were subjected to one-way analysis of variance (ANOVA) as a completely randomized design under statistical analysis system software (SPSS, 2012). Significant differences between treatment means were compared by Duncans multiple range test (Duncan, 1955) and were considered to be statistically significant at P< 0.05.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition and Metabolizable Energy of Test Ingredient (BSOPM)

The biodegradable sweet orange fruit peel meal (BSOPM) crude protein (CP) value of 7.58% is similar to 7.71% report of Hon *et al.*, (2009) for sweet orange fruit peel meal, 7.22% CP for soaked sweet orange fruit peel [6], 7.40% CP [7] and 7.71% CP [8] for sundried sweet orange peel; but lower than 10.96% CP [9], 10.73% CP [10] and 8.20% CP [11], for sweet orange peel meal. The CP value of the test ingredient is also lower than the CP of 9.10, 9.25, and 10.65%

reported for maize by Aduku (1995), Tuleun *et al.*, (2005) and Gbenge and Ikurior, (2019). The differences in CP values could be attributed to differences in soil types, age at maturity, genetic variation, topographical location, season of the year where the peels were gathered and processed, processing and handling methods of the peels and the stage of maturity at which the fruits were harvested.

The crude fibre value (11.11%) of this study is higher than 9.58% [8] and 7.86% [10] for sun-dried sweet orange peel meal but lower than 12.76% CF, 13.50% CF and 13.30 % CF reported by Ojabo *et al.*, (2014) and Sunmola *et al.*, (2018), respectively. This suggests that, the processing technique adopted in this study caused a reduction in the crude fiber content of the sweet orange peel.

Ether extract (EE) value of 2.89% is comparable with 2.70 % and 2.29 - 2.95 % [3] for fermented sweet orange fruit peel. The EE value of this study is however lower than 3.31 % EE value of sweet orange fruit peel meal (Oluremi *et al*., 2008). Differences in EE values could be attributed to the degrading activities of microbial presence in the rumen filtrate occasioned to be of beneficial use by taking advantage of its microbial population rather than its present status as an agricultural waste (Oluremi *et al*., 2018). The percentage total ash (TA) content of 11.58% obtained in this study is slightly lower than the value of 12.00% TA by Agu *et al.*, (2010) for sweet orange fruit peels but higher than 5.18, 3.17, 7.19 and 6.09% by Hon *et al.*, (2009), Ojabo *et al.*, (2014), Ahaotu *et al.*, (2010)) and Sunmola *et al.*, (2018) for sweet orange fruit peels and sweet orange fruit pulp meal. The level of ash content in this study suggests that, the test ingredient (BSOP) is a good source of mineral elements which is needed for proper fluid balance, healthy bones, beak and scales formation.

However, the nitrogen free extract (NFE) of 66.84% in this study is higher than the values of 56.91 and 62.65% reported by Agu *et al.*, [10] and Ojabo *et al.*, [7] but lower than 75.31% report of Hon *et al.*, [5]. The NFE value of 66.84% of this study may implied that, BSOPM has a high level of soluble carbohydrate will enhance palatability, increase feed intake and digestibility. The metabolizable energy (ME) value of 2854.24 kcal/kg of the test ingredient observed in this study revealed that, the biodegraded sweet orange peel is inferior to maize whose ME revealed 3432, 3271, 3454 and 3416.29kcal/kg metabolizable energy (ME) as reported by Aduku and Olukosi (1995) Abubakar *et al., (*2006*)*; Igwebuike *et al.*, (2013) and Gbenge and Ikurior [14]. It is also lower than the reported values of 3756.14 kcal/kg [10], 3079.61 kcal/kg [Sunmola, et al., (2018), 3752.12 kcal/kg [Ahaotu, *et al*., (2018) 3988.70 kcal/kg (Agu et al., 2010) and 3674.44 kcal/kg (Ojabo *et al*.,2014) for unfermented sweet orange peels and sweet orange fruit pulp meal but higher than 2732.50.73 and 2648.82 kcal/kg ME reported values of Oluremi *et al.*, (2008) and Akpe *et al.*, (2019) when biodegraded sweet orange peel meal was used to replace maize in the diets of broiler chicken. By implication, this result has revealed that biodegradation of sweet orange peel meal has reduced its energy value.

3.2 Growth Performance of Broiler Chickens Fed Biodegraded Sweet Orange Peel Meal:

3.2.1 Based diets

The mean final live body weight of the broiler chickens in this study differed significantly ($p<0.05$) across the dietary treatments. The values ranged from 1582.64 g (T0) to 789.68 g (T25).

This suggests that the control maize-based diet supported a faster growth rate. This is possibly due to the effect of the nutritive quality of maize in relation to BSOPM. This result also agreed with the findings of Yang and Chung (1985) who reported that body weight and weight gain were negatively affected as the level of citrus in poultry diet increased compared to control.

Table 3. Proximate ingredient composition of biodegradable sweet orange peel meal (BSOPM)

Parameters	**BSOPM**
Dry matter (%DM)	89.60
Crude protein (%CP)	7.58
Crude fibre (%CF)	11.11
Ether extract (%EE)	2.89
Total ash (%TA)	11.58
Nitrogen free extract (%NFE)	66.84
ME (kcal/kg)	2854.24

Metabolizable Energy (ME) = calculated according to the formula of Pauzenga (1985) while NFE) was also calculated as described by Association of Official Analytical Chemists (AOAC, 2006), ME= 37×%CP+81.8×%EE+35.6×%NFE while %NFE = 100 – (%CP + %CF + %EE + %Ash). ME and %NFE were calculated as referenced by Etuk et al., (2012); Igwebuike et al., (2014)

Table 4. Growth performance of broiler chickens fed diets containing graded levels of biodegradable sweet orange fruit peel meal Experimental Diets

Parameters	**T_0**	**T_5**	**T_{10}**	**T_{15}**	**T_{20}**	**T_{25}**	**SEM**
Average initial weight (g)	41.17	39.67	39.67	38.67	40.33	38.67	0.61NS
Average final weight gain (g)	1582.64^{a}	1512.20^{a}	1462.49^{a}	1365.28^{ab}	977.78^{a}	798.68^{a}	99.20
ADFI (g/day)	67.92^{ab}	62.77^{bc}	62.58^{bc}	69.50^{a}	61.84^{bc}	57.47^{c}	2.06*
ADWG (g/day)	24.47^{a}	23.37^{a}	22.58^{a}	21.06^{a}	14.88^{b}	11.92^{b}	1.57
Feed conversion ratio (FCR)	4.17^{b}	4.41^{b}	4.05^{b}	5.04^{b}	5.00^{a}	4.77^{a}	0.26*
Mortali	2.67	2.33	3.33	3.00	2.67	3.00	0.72NS

ty (%)

*Means (a,b,c) on the same row with different superscripts differs significantly (p<0.05), * = Significant (p<0.05) difference, SEM = Standard error of mean, NS = No significant (p>0.05) difference, ADFI = Average daily feed intake and ADWG = Average daily weight gain*

T0 = Control diet containing 0%BSOPM
T5 = Diet containing 5%BSOPM
T10 = Diet containing 10%BSOPM
T15 = Diet containing 15%BSOPM
T20 = Diet containing 20%BSOPM
T25 = Diet containing 25%BSOPM
BSOPM = biodegradable Sweet Orange Peel Meal

The high crude fiber level contained in the orange peel could be implicated to it negative effects on broiler performance (Soltani *et al.,* 2012). Close (1993) observed that, there was a reduction in energy intake with increased in fiber intake which reduces both growth and energy utilization, therefore due to the higher fiber content of SOPM relative to maize. This result is in agreement with Oluremi *et al.*, (2010) and Agu *et al.*, (2010) who reported that, broiler chickens on control diets were heavier than those on sweet orange peel meal-based diets. Significant differences in daily feed intake obtained in this study were within reported range of 52.68 g to 62.56 g by Agu *et al.*, (2010) when sundried sweet orange peel meal was used to replace maize at levels of 0 - 50 % in broiler starter diets but lower than the daily feed intake range of 135.98 g to 160.89 g earlier report (Agu *et al.*, 2010)] when sun-dried sweet orange peel meal was used to replace dietary maize in broiler finisher chicken diets. This finding is in agreement with the report of Ani *et al.*, (2015) who reported that feed intake significantly decline at all the sundried SOPM inclusion level in the diet of broiler chicken. This result is also in agreement with the findings of Abbas *et al.*, (2013) who reported significantly reduction in the feed intake of the broiler at all inclusion levels of SOPM compared to the birds fed on control diet. Variations with the previous findings may be attributed to the differences in the processing techniques of the sweet orange peel, environment, breeds/strains of the experimental broiler chickens. It was observed that birds fed diets containing biodegraded sweet orange peel meal had similar daily feed intake and feed conversion ratio.

The daily weight gain (11.92 g to 24. 47 g) obtained for broiler finisher chickens in this study were within the range of 19 g as stated by Aduku (2000) for starter broiler chicks. The depressed growth rates in birds fed T0 to T25 (24. 47 g to 11.92 g) can be attributed to poor utilization of dietary nutrients as a result of higher dietary crude fiber level caused by maize replacement with BSOPM. The significant difference in feed conversion ratio (FCR) of 2.71– 4.13 obtained in this study was within the range of 2 to 5 recommended by Oluyemi and Robert (2000) as normal for broiler chicken irrespective of the dietary treatment and comparatively within 2.83 to 3.59 [10] and 2.61 to 3.20 [8]. Feed conversion rate is low for young animals when relative growth is large and increases for older animals when relative growth tends to level out. Broiler chickens fed control diet significantly differed from T15 and T25 with the best feed conversion efficiency at T5 (2.71) compared to the broiler chickens fed control and SOPM based diets [(Aduku et al., 2000) (Oboh, 2006)].

Mortality recorded (2.67 – 3.33%) could not be linked to the effect of the experimental diets since T_0 (0% BSOP replacement) and BSOP based diets recorded similar mortality rate.

Mortality cut across the dietary treatments and the trend makes it difficult to attribute it to either the experimental diets or the BSOP which was the test ingredient. It appears that mortality was more of environmental effect which might be associated to sudden heat stress. Also, previous reports on sweet orange peel meal have recorded 0% mortality even at higher percentages of maize replacement ((Oluremi *et al*., 2008).). This suggests that, biodegradation of sweet orange peel using rumen filtrate did not improve the feed quality of sweet orange peel for growth performance.

3.3 Effect of Experimental Diets Containing Different Levels of Biodegradable Sweet Orange Peel Meal on Nutrient Digestibility of Broiler Chickens

The digestibility of dry matter and all nutrients did not vary significantly (p>0.05) across the dietary treatments, values were however observed to be higher in birds in the control group. The values for dry matter digestibility recorded range from 89.02 (T25) – 91.09% (T0). Non-significant differences may indicate that, the crude fiber levels of experimental diets did not have negative effect on the overall digestibility of the dry matter. Also, it may indicate that, adequate nutrient was available for growth and maintenance. Crude proteins recorded vary from 85.33 – 89.10% for the broiler chickens fed BSOPM and control diet showed no significantly differences among the treatment groups. The non-significant differences recorded may also be attributed to none adverse effect of crude fiber levels of the experimental diet. McDonald *et al.,* (1995) who observed that, high dietary fiber levels above the recommended level (6% CF) may adversely affect the nutrient utilization.

Ether extract (EE) ranged from 92.94 – 94.54 % for the broiler chickens fed BSOPM and control diet. EE is also referred to as oil, its effectiveness in digestibility may be attributed to normal dietary fiber which enhanced the digestible ability of lipase enzyme on dietary fat. Result of this study on EE digestibility coefficient for the broiler chickens fed BSOPM and control diet showed significant differences among the treatment groups. This may also mean that, the diets had optimum mineral nutrients to enhanced homeostatic balance and structural build-up of the broiler chickens [(Orayaga *et al.,* 2016) and (Pauzenga, 1985)].

Crude fibre digestibility of broiler chickens fed experimental diets had a high and least value in T20 (79.24%) and T0 (75.20%) respectively. Digestibility of nutrient is opined to be affected by the nature of the feed in terms of crude fibre content (McDonald *et al.,* 1995). The non-significant (p>0.05) result of this study on crude fibre digestibility of nutrient obtained is an indication that, BSOPM had no deleterious effect on the experimental diets. Result of this study on crude fibre digestibility of nutrient agreed with report by Cabotaje *et al.,* (1992) that, decreased nutrients digestibility can be attributed to shorter resident time of the more fibrous diets in the intestine of monogastrics. Nitrogen free extract represents the readily available carbohydrate present in the diet and in this study, the digestibility of nitrogen free extract ranged from 92.77 - 94.00% for the broiler chickens fed BSOPM and control diet. The no significant differences showed that, the broiler chickens fed control and BSOPM based diets efficiently digested the readily available carbohydrate in the diets.

3.4 Haematological Indices of Finisher Broiler Chickens Fed Biodegraded Sweet Orange

3.4.1 Peel meal based diets

The haematological parameters of broiler chickens fed control diet and BSOPM based diets are presented in Table 5. The results obtained in this study showed that, PCV, RBC, Hb, WBC, MCHC, MCH and Leucocyte differential counts (Lymphocytes, heterophil, basophil and monocytes) were not significantly different (P>0.05) between the dietary treatment groups as compared with control group, while significant differences (P>0.05) were observed only on mean values of MCV across the dietary treatments. The PCV, Hb, RBC, WBC, MCH, MCHC and leucocytes differential counts (heterophil, lymphocytes, eosinophil, basopil and monocytes) of the finisher broiler chickens fed biodegraded sweet orange peel meal-based diets were not significantly different except MCV. This implies that the replacement of up to 25% maize with BSOPM in finisher broiler chickens diet had no adverse effect on these critical health status indicators, since values obtained from these parameters were within documented normal range for healthy chickens.

Table 5. Effect of experimental diets on apparent nutrient digestibility of finisher broiler chickens Experimental diets

Parameters	T0	T5	T10	T15	T20	T25	SEM
Dry matter (DM)	91.09	89.82	89.18	89.48	89.51	89.02	0.338 NS
Crude protein (CP)	89.10	86.69	85.32	85.54	86.26	87.03	0.495 NS
Crude fiber (CF)	75.20	77.14	77.31	76.97	79.23	76.78	0.798 NS
Ether extract (EE)	94.54	93.59	93.74	92.94	93.08	93.47	0.358NS
Nitrogen free extract (NFE)	94.00	93.35	92.77	93.42	92.95	92.34	0.261 NS

*Means (a,b) on the same row with different superscripts differs significantly (p<0.05), * = Significant (p<0.05) difference, NS = No significant (p>0.05) difference, SEM = Standard error of mean, TDN is calculated using the formula of Church et al., (1988). TDN = Digestible CP + Digestible NFE +2.25 x Digestible EE+ Digestible CF.*

Sources: Iyeghe – Erakpotobor (2009) and Hadiza (2019)

T0 = Control diet containing 0%BSOPM

T5 = Diet containing 5%BSOPM

T10 = Diet containing 10%BSOPM

T15 = Diet containing 15%BSOPM

T20 = Diet containing 20%BSOPM
T25 = Diet containing 25%BSOPM
BSOPM = biodegradable Sweet Orange Peel Meal

Table 6. Haematological profile of finisher broiler chickens fed diets containing graded levels of biodegradable sweet orange fruit peel meal Experimental Diets

Parameters	T0	T5	T10	T15	T20	T25	SEM
PCV (%)	31.00	29.67	29.67	29.33	30.00	29.33	1.75NS
RBC (×1012/l)	2.10	2.23	2.73	2.33	2.33	2.10	0.20NS
WBC (×109/l)	7.13	6.70	6.40	6.33	6.27	7.17	2.71NS
Hb (g/dl)	10.33	9.97	9.90	9.77	9.87	9.10	0.678NS
MCV (fl)	147.73a	134.43a	89.90b	129.80a	129.80a	140.03a	8.87*
MCH (pg)	48.70	44.87	39.90	43.20	43.03	43.97	3.30NS
MCHC (g/dl)	33.33	33.33	33.33	33.27	33.20	33.03	0.18NS
Leucocyte Differential Counts (%)							
Lymphocytes	51.67	49.33	48.67	46.67	49.33	51.00	3.05NS
Heterophil	47.00	47.33	48.33	48.33	46.67	47.67	3.31NS
Eosinophil	1.00	1.00	0.00	1.67	1.33	0.33	0.71NS
Basophil	0.00	0.00	0.00	0.00	0.00	0.00	0.00NS
Monocytes	0.33	2.67	2.33	3.33	2.67	0.33	0.78NS

*Means (a,b) on the same row with different superscripts differs significantly (p<0.05), * = Significant (p<0.05) difference, NS = No significant (p>0.05) difference, SEM = Standard error of mean, * = Significant (p<0.05) difference, PCV= Packed cell volume, RBC= Red blood cell count, WBC= White blood cell count, Hb=Haemoglobin concentration, MCV= Mean corpuscular volume, MCH= Mean corpuscular haemoglobin and MCHC= Mean corpuscular haemoglobin concentration*
T0 = Control diet containing 0%BSOPM
T5 = Diet containing 5%BSOPM
T10 = Diet containing 10%BSOPM
T15 = Diet containing 15%BSOPM
T20 = Diet containing 20%BSOPM
T25 = Diet containing 25%BSOPM
BSOPM = biodegradable Sweet Orange Peel Meal

4. CONCLUSION

From results obtained from this study it can be inferred that whereas the health and nutrient digestibility of broiler chickens were not significantly affected by the replacement of up to 25% dietary maize with biodegraded sweet orange peel meal, performance of these chickens were significantly depressed.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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