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Growth performance, blood parameters and production cost of broiler chickens fed dietary sweet orange peel meal diets with and without enzyme addition

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Abstract

The growth performance, blood parameters and production cost of two hundred and fifty two (252) Abor acre plus broiler chickens fed sweet orange peel meal (SOPM) with and without enzymes were investigated. The experimental diets consist of control (T_0), maize was replaced with SOPM at 15, 20 and 25 % without exogenous enzymes to form T_1, T_2 and T_3 respectively, and another supplemented with exogenous enzyme to form T_4, T_5 and T_6 respectively. The birds were randomly allocated to seven treatment groups replicated three times to have 12 birds per replicate and were fed experimental diet ad-libitum for eight weeks. Result showed that broiler chickens fed control diet (T_0) had significantly ($P<0.05$) higher final weight (FW) of 2.44kg, weight gain (WG) of 42.91, feed intake (FI) of 86.53, better feed conversion ratio (FCR)of 2.01 and protein conversion ratio (PCR)of 0.44 compared to other dietary treatments. Broiler chickens fed T_1 and T_4 had significantly ($P<0.05$) higher final weight of 1.98 and 1.98 kg, weight gain of 34.69 and 34.71 g and feed intake of 78.35 and 81.63 g respectively while significantly ($P<0.05$) least values of 1.75 and 1.80 kg final weight, 30.73 and 31.49 g weight gain and 69.47 and 71.84 g feed intake respectively were recorded in broiler chickens fed T_2 and T_5. Haematological indices namely: PCV, RBC, WBC and Hb were not significantly different ($P>0.05$) but MCV, MCH, MCHC, lymphocytes, heterophil, eosinophil and monocytes differed significantly ($P<0.05$). Serum biochemical indices namely total protein, albumin, globulin and uric acid were significantly ($P<0.05$) influenced by the experimental diets. Though, there was no detrimental effect of SOPM and enzyme on production cost as profit was made at all replacement levels of SOPM with and without enzyme treatment, but profit per bird (₦) and cost to benefit ratio revealed the superiority of the broiler chickens fed control diet (T_0). Based on the results obtained, SOPM can replace maize up to 25 % without posing any deleterious effect on the broiler chickens growth performance, blood parameters and production cost. However, the cost to benefit ratio was compromised with the use of SOPM.

Keywords: broiler; performance; orange peel; polyzyme®; blood parameters; economics

Introduction

The demand for eggs and poultry meat has significantly increased in recent years across large parts of the continent, due to the high population growth in Africa and growing income (World Health Organization, 2014). According to estimates by the USAID (United States Agency for International Development), this trend is very likely to continue over the next few years. Therefore, the consumption of poultry meat and eggs will increase by 200 % between 2010 and 2020 for some countries in sub-Saharan Africa (Obi, 2003; USDA, 2013). One African country where this trend can clearly be seen is Nigeria with estimated population of 174.5 million people in 2013 and at the growth rate of 3 % per annum (USDA, 2013). The Nigerian poultry industry in particular has been rapidly expanding in recent years and is therefore one of the most commercialized (capitalized) subsectors of Nigerian agriculture (Adene and Oguntade, 2006;

USDA, 2013). Nutrition is the most important consideration in poultry industry and its survival is dependent on the availability of feedstuffs, which are mainly components of human food e.g maize (Esonu *et al.,* 2006). However, feed cost is presently very high and makes up to 70 – 80 % of the total cost of production in Nigeria compared to 50 to 70 % in developed countries (Thackie and Flenscher, 1995). Several attempts have been made to reduce the cost of farm animal production by replacing percentages of maize with agro-industrial by-products such as maize offal, wheat offal, rice offal, cassava peel, brewers dried grain (Ibiyo and Atteh, 2005). A number of residue materials like peels, rag, seed (Chapman *et al*., 2000) are produced when fresh citrus fruits are processed into juice, concentrate and canned fruit in developed countries or when they are peeled for direct human consumption as in the case of most developing countries like Nigeria. These by-products can be processed into wet and dried citrus pulp, citrus molasses, citrus meal and citrus seed meal. Various studies on feeding value of these citrus by-products showed that citrus by-products can be utilized for monogastric animals (Oluremi *et al*., 2006). Nutritional trials with monogastric animals have shown that the meal of sun dried peels of *Citrus sinensis* can replace dietary maize in broiler chickens diet up to 20 % (Agu, 2006). The present work was done to evaluate the potential use of sweet orange peel meal with and without enzymes in broilers′ diets on growth performance, blood parameters and economic of production.

Materials and methods

Experimental site

The study was conducted at the Poultry Unit of the Livestock Teaching and Research Farm, Federal University of Agriculture, Makurdi, Benue State. Makurdi is located between latitude $7^0 44'$N and longitude $8^0 21'$E in the Guinea Savanna Zone of West Africa. The area has an annual rainfall between 6 - 8 months (May - October) and ranges from 508 to 1016 mm with a minimum temperature range of 24.20 ± 1.4^0C and maximum temperature range of 36.33 ± 3.70^0C. The relative humidity ranges between 39.50 ± 2.20% and 64.00 ± 4.80% (TAC, 2011).

Collection and preparation of test ingredients

Fresh sweet orange (*Citrus sinensis*) fruit peel was collected from orange retailers on the university campus and immediately sun-dried to a moisture content of less than 12 % moisture. It was milled to obtain the sweet orange peel meal which was mixed with other feed ingredients to produce the experimental diets. The enzyme used in this study was "POLYZYME®. The polyzyme® contains xylanase, phytase, cellulase, β – glucanase, pectinases, α – amylase, protease, α – galactosidase, β – galactosidase, lipase and mannanase all of which are able to digest complex carbohydrates at the manufacturer recommendation dose of 400gm per ton of mash feed.

Experimental design and diets

Two hundred and fifty two (252) *Abor acre plus* chicks (one day old) were used in the experiment. The experiment was divided into seven (7) treatments with replacement levels of 15, 20 and 25 % sweet orange peel meal (in partial replacement of white maize) with or without enzyme supplement and also a control. Each treatment consisted of three replicates. The experimental groups are as follows: Group = T_0: control (Control without SOPM and Enzyme), Group 2 = T_1: 15 % SOPM without Enzyme, Group 3 = T_2: 20 % SOPM without Enzyme, Group 4 = T_3: 25 % SOPM without Enzyme, Group 5 – T_4: 15 % SOPM + Enzyme, Group 6 = T_5: 20 %

SOPM + Enzyme, Group 7 = T_6: 25 % SOPM + Enzyme. The experimental diets were formulated according to the Aduku (2005) recommendations to meet the nutrient requirements of broiler chicks from day 1 to 28 (starter diet) and from day 29 to 42 (finisher diet). The starter diets contained between 22 – 24 % CP and 2800 - 2900 kcal ME/Kg and the finisher diet contained 20 - 22 % CP and 2900 - 3100 kcal ME/Kg. The gross and nutrients composition of the experimental and control diets used at both broiler starter and finisher phases are shown in Tables 1 and 2. Feed and water were provided *ad-libitum* throughout the 56 days experimental period.

Data collection

Feed intake was calculated as difference in the quantity of feed given and left over after 24 hour. Weight gain was determined weekly. Feed: grain ratio was calculated from feed intake and weight gain. Protein conversion ratio was calculated by multiplying feed intake by dietary protein intake divided by body weight gain. Cost of feed was calculated from the cost of ingredients used in feed preparation. Feed cost per kilogram live weight gain was calculated from feed cost and feed: gain ratio. Feed cost per weight gain was calculated by multiplying the feed cost per kg with total feed intake and divided by total weight gain. Feed cost/chick was calculated by multiplying feed intake per day by the number of days and by feed cost per kilogram. Operational cost per bird was calculated by adding all other expenses except expenses on feed and day old broiler chick. Cost savings due to SOPM was calculated by subtracting total cost of production of each treatment from total cost of production of the broiler chickens fed control diet. Total cost of production was calculated by adding cost of day old chick, feed cost per chick and operational cost. Feed cost as a percentage of total production cost was calculated by dividing cost of feed per kg with total cost of production and multiply by hundred. Income per bird was calculated by multiply average live weight by selling price per kilogram live weight. The profit per bird was calculated by subtracting expenses from income. Cost: benefit ratio was calculated by dividing the expenses with income.

Nutrient digestibility

Determination of nutrient digestibility was done from 49 to 56 days of the experimental period. Two birds per replicate were selected and transferred into metabolic cages. A 3-days acclimatization period was allowed for the birds and the respective diets were offered liberally. Daily feed intake and daily faecal output were recorded for 4 days. The feacal droppings were collected per replicate once daily at 8:00 am, weighed and dried in an oven at 70°C to constant weight. Dried feacal were bulked and ground. Feed and feacal were used to determine their respective proximate constituent according to the standard method of (AOAC, 2006) while the metabolizable energy was calculated using the equation; ME (kcal/kg) = 37 x % CP + 81.1 x % EE + 35.5 x % NFE (Pauzenga, 1985).

The coefficient of digestibility was calculated using the formula below:

$$\text{Coefficient of digestibility} = \frac{\text{Nutrient in feed} - \text{Nutrient in feace}}{\text{Nutrient in feed}} \times 100$$

Blood constituent evaluation

At the 8th week of the experiment, birds were fasted overnight so that the serum was cleared of excess fat and protein that could cloud the results. Three (3) birds per treatment replicates of average mean weight were selected for the evaluation of haematological indices and serum biochemical variables. Two (2) mL of blood samples was collected from the birds that were slaughtered using a sharp and cleaned knife, during bleeding; the blood was drained into labelled sterile bottle containing ethylene diaminetetra acetic acid (EDTA) which served as an anticoagulant.

Table 1 : Gross composition of the experimental broiler starter diets

	Experimental diets						
Ingredients	T_0	T_1	T_2	T_3	T_4	T_5	T_6
White maize	52.60	44.71	42.08	39.45	44.71	42.08	39.45
SOPM	-	7.89	10.52	13.15	7.89	10.52	13.15
Soya bean meal	37.35	37.35	37.35	37.35	37.35	37.35	37.35
Rice bran	3.25	3.25	3.25	3.25	3.25	3.25	3.25
Blood meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Palm oil	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Herbo-Methionine	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25
L-Lysine	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Common salt	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Enzyme	-	-	-	-	+	+	+
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Calculated analysis							
**ME (Kcal/kg)	2925	2888	2876	2864	2888	2876	2864
Crude protein (%)	23.15	23.82	22.98	22.93	23.82	22.98	22.93
Crude fibre (%)	4.38	5.19	5.46	5.77	5.19	5.46	5.77
Ether extract (%)	3.63	3.94	4.04	4.14	3.94	4.04	4.14
Lysine (%)	1.48	1.46	1.45	1.45	1.46	1.45	1.45
Methionine (%)	0.64	0.62	0.61	0.61	0.62	0.61	0.61
Calcium (%)	1.04	1.04	1.04	1.04	1.04	1.04	1.04
Available P (%)	0.89	0.87	0.86	0.84	0.87	0.86	0.84

**Premix per kg of diet vitamin A – 15,000.00IU, Vitamin D3 - 3, 000,000IU, Vitamin E - 30,000IU,Vitamin K3,000mgVitamin B1 3000,mg Vitamin B2-6000mg, Vitamin B- 5,000mg, Vitamin B12-40mg, Biotin 200mg, Niacin-40,000mg, Pantothenic acid 15,000mg,Folic acid 2,000mg, choline 300,000mg,Iron 60,000mg, manganese 80,000mg, copper 25,000mg,Zinc 80,000mg cobalt 150mg,iodine 500mg, selenium 310mg, Antioxidant 20,000mg.*

***MEkcal/kg calculated using 37 X % CP + 81.1 X % EE + 35.5 X % NFE (Pauzenga, 1985): SOPM = Sweet orange peel meal; (-) = No enzyme; (+) = 0.04% with enzyme; P = Phosphorus; ME = Metabolizable energy; T_0 = Control diet (without SOPM and enzyme); T_1 = 15 % SOPM without enzyme; T_2 = 20 % SOPM without enzyme; T_3 = 25 % SOPM without enzyme; T_4 = 15 % SOPM with enzyme; T_5 = 20 % SOPM with enzyme; T_6 = 25 % SOPM with enzyme*

Haematological indices determined were packed cell volume (PCV), red blood cell count (RBC), white blood cell count (WBC) and haemoglobin concentration (Hb). The improved Nuebaer Haemocytometer method described by Jain (1986) was used to estimate the red and white blood cells, haemoglobin were determined according to Jain (1986). PCV was determined using Wintrobe Microhaematocrit method (Dacie and Lewis, 1991). The determination of the distribution of the various blood cells was done by Shilling method of differential leucocyte counts (Mitruka and Rawnsley, 1977) and mean corpuscular haemoglobin concentration (MCHC), mean corpuscular volume (MCV) and mean haemoglobin concentration (MHC) was computed according to Jain (1986).

A second set of anti-coagulant free bottle tubes were used to collect 3mL of blood sample from each bird for serum biochemical analysis. The blood was allowed to clot to obtain serum by allowing the blood sample to stand for 2 hours at room temperature and centrifuged using the High Speed Wintrobes Microhaematocrit for 10 minutes at 2000 rpm to separate the

Table 2: Gross composition of the experimental broiler finisher diets

	Experimental diets						
Treatments	T_0	T_1	T_2	T_3	T_4	T_5	T_6
Ingredients							
White maize	57.65	49.46	46.73	44.00	49.46	46.73	44.00
SOPM	-	8.19	10.92	13.65	8.19	10.92	13.65
Soya bean meal	32.05	32.05	32.05	32.05	32.05	32.05	32.05
Rice bran	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Blood meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Bone meal	3.00	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	1.50
Herbo-Methionine	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25
L-Lysine	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Common salt	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Enzyme	-	-	-	-	+	+	+
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Calculated analysis							
**ME/kcal/kg	3005	2968	2955	2943	2968	2955	2943
Crude protein (%)	21.24	21.10	21.06	21.02	21.10	21.06	21.02
Crude fibre (%)	4.08	4.95	5.24	5.53	4.95	5.24	5.53
Ether extract (%)	3.62	3.93	4.03	4.13	3.93	4.03	4.13
Lysine (%)	1.35	1.33	1.32	1.31	1.33	1.32	1.31
Methionine (%)	0.60	0.58	0.57	0.57	0.58	0.57	0.57
Calcium (%)	1.04	1.03	1.03	1.03	1.03	1.03	1.03
Available P (%)	0.87	0.84	0.84	0.83	0.84	0.84	0.83

**Premix per kg of diet vitamin A – 15,000.00IU, Vitamin D3 - 3, 000,000IU, Vitamin E - 30,000IU, Vitamin K – 3,000mgVitamin B1 3000,mg Vitamin B2-6000mg, Vitamin B- 5,000mg, Vitamin B12-40mg, Biotin 200mg, Niacin-40,000mg, Pantothenic acid 15,000mg,Folic acid 2,000mg, choline 300,000mg,Iron 60,000mg, manganese 80,000mg, copper 25,000mg,Zinc 80,000mg cobalt 150mg, iodine 500mg,selenium 310mg, Antioxidant 20,000mg.*

***MEkcal/kg calculated using 37 X % CP + 81.1 X % EE + 35.5 X % NFE (Pauzenga, 1985): SOPM = Sweet orange peel meal; (-) = No enzyme; (+) = 0.04% with enzyme; P = Phosphorus; ME = Metabolizable energy;* T_0 = *Control diet (without SOPM and enzyme);* T_1 = *15 % SOPM without enzyme;* T_2 = *20 % SOPM without enzyme;* T_3 = *25 % SOPM without enzyme;* T_4 = *15 % SOPM with enzyme;* T_5 = *20 % SOPM with enzyme;* T_6 = *25 % SOPM with enzyme*

cells from the serum. Serum total protein, globulin, albumin and urea acid was analysed using Sigma kits according to Benzie and Strain (1996).

Chemical analysis

Proximate composition of sweet orange peel meal, feeds and feaces were determined using AOAC (2006) methods of analysis, while the metabolizable energy was calculated using the equation; ME (kcal/kg) = 37 x % CP + 81.1 x % EE + 35.5 x % NFE (Pauzenga, 1985).

Statistical analysis

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

Results and discussion

The proximate composition and energy content of sweet orange peel meal and maize used in this study is shown in Table 3. The proximate composition of sweet orange peel meal (*Citrus sinensis*) had crude protein (CP) and metabolizable energy (ME) contents of 8.20 % and 3079.61 kcal/kg ME compared with the CP of 9.20 % and metabolizable energy of 3432.32 kcal/kg reported by Aduku (2005). The CP of 8.20 % in the peels was lower than CP in maize, a conventional energy feedstuff with CP content of 9.25 % (Tuleun *et al*., 2005), while crude fibre (CF) of 13.30

% in the peel was higher than 2.20 % CF reported for maize. This showed that sweet orange peel meal has comparative energy level with maize, though high crude fibre (13.3 %) in the peel may reduce its feeding value in poultry nutrition compared to maize with 1.3 % crude fibre.

Table 3 : Proximate composition and energy content of sweet orange (Citrus sinensis) peel meal and maize (% DM)

	Feedstuff	
Nutrients (%)	[1]SOPM	[2]Maize
Dry matter	89.20	86.50
Crude protein	8.20	9.10
Crude fibre	13.30	1.30
Ether extract	4.51	4.00
Ash	6.09	2.70
Nitrogen free extract	67.90	83.00
[3]ME kcal/kg	3079.61	3432.32

[1]Laboratory Analysis; [2]Aduku (2005); [3]Metabolizable energy as determined using Pauzenga (1985), SOPM = Sweet orange peel meal

Performance of finisher broiler chickens fed diets containing SOPM with and without enzyme treatment and control diet is shown in Table 4. Initial weight of all groups of broiler chickens ranged between 33.43 – 33.63 g/bird. The final body weight ranged from 1.75 to 2.44 kg/bird. Broiler chickens fed control diet recorded a significantly (P<0.05) highest final body weight than broiler chickens fed SOPM based diet with and without enzyme treatment.

Table 4 : Effect of dietary sweet orange peel meal with and without enzyme treatment on finisher broiler chickens growth performance

TRT	AIW (g)	AFI (g/d)	AWG (g/d)	AFW (kg)	FCR	PCR	MOT
T_0	33.43	86.53^{a}	42.91^{a}	2.44^{a}	2.01^{a}	0.44^{a}	2.77
T_1	33.53	78.35^{bc}	34.69^{b}	1.98^{b}	2.25^{b}	0.48^{b}	0.33
T_2	33.63	69.47^{d}	30.73^{c}	1.75^{c}	2.27^{b}	0.48^{b}	0.66
T_3	33.53	73.19^{cd}	30.72^{c}	1.75^{c}	2.38^{bc}	0.51^{bc}	0.33
T_4	33.53	81.63^{ab}	34.71^{b}	1.98^{b}	2.35^{bc}	0.50^{bc}	0.66
T_5	33.63	71.84^{d}	31.49^{bc}	1.80^{bc}	2.28^{b}	0.49^{b}	0.00
T_6	33.63	73.81^{cd}	30.02^{c}	1.73^{c}	2.46^{c}	0.52^{c}	0.00
SEM	0.00^{ns}	1.80^{*}	1.03^{*}	0.09^{*}	0.05^{*}	0.02^{*}	0.18^{ns}

*[a,b,c,d]Means within each column with different superscripts are significantly different (P< 0.05). ns - not significantly different (P>0.05); * Significantly different (P<0.05);AIW = average initial weight; AFW = average final weight; AWG = average weight gain; AFI = average feed intake; FCR = feed conversion ratio; PCR = Protein conversion ratio; SEM = standard error of mean; SOPM – Sweet orange peel meal; T_0 = Control diet (without SOPM and enzyme); T_1 = 15 % SOPM without enzyme; T_2 = 20 % SOPM without enzyme; T_3 = 25 % SOPM without enzyme; T_4 = 15 % SOPM with enzyme; T_5 = 20 % SOPM with enzyme ; T_6 = 25 % SOPM with enzyme*

This agreed with the findings of Agu *et al.* (2010) who reported a significantly (P<0.0) lower value in final body weight of the broiler chickens fed diets containing SOPM. The result also conformed to that of Ani *et al*. (2015) who reported that increasing levels of processed SOPM from 5 % to 20 % significantly decreased the average final body weight and weight gain compared with the birds fed control diet. The result is also in line with that of Ojabo and Adenkola (2014) who reported significant differences in final body weight and weight gain of the broiler chickens fed sun-dried SOPM. The significantly (P<0.05) lower value of body weight and weight gain recorded in broiler chickens fed SOPM based diets may be associated with the higher crude fibre and other associated intrinsic factors compared to the control. The high crude fibre level contained in the orange peel can precipitate negative effects on broiler performance (Ayed *et al.,* 2011; Soltani *et al.,* 2012). Close (1993) observed a reduction in energy intake with increasing fibre level which reduces both energy utilization and growth. This result was not consistent with the findings of Abdel-moneim *et al.* (2014) that replacing the yellow corn with orange waste in broiler diet did not cause any significant changes in the broiler chickens performance at all replacement levels with and without enzyme treatment. The higher final body weight and weight gain recorded on broiler chickens fed diet containing 15 % SOPM with and without enzyme treatment collaborated with the findings of Oluremi *et al. (2006)* that sweet orange rind could replace maize in broiler chickens diet up to 15 % level without any undesirable effect on performance. The result obtained showed that protein conversion ratio was better with the lower levels of dietary SOPM in both treatment groups. The significantly ($P<0.05$) higher daily feed intake (g/bird) recorded in broiler chickens fed control diet compared to the broiler chickens fed sweet orange based diets was in agreement with the report of Ani *et al.* (2015) that feed intake significantly declined with dietary SOPM inclusion. The result of this study also agreed with the findings of Abbas *et al*. (2013) on significant reduction in feed intake of broiler chickens at all inclusion levels of dietary SOPM compared to the broiler chickens fed control diet but differed from Abdel-moneim *et al.* (2014) that replacing yellow corn with orange waste in broiler chickens diet did not cause any significant changes in feed intake of the chickens at all replacement levels with and without enzyme treatment. Ali *et al.* (2013) also reported a significant influence on feed intake when broiler chickens were fed different levels of dried lemon pulp. The reduction in feed intake could be attributed to a decrease in palatability of the diets with dietary inclusion of peel. Oluremi *et al.* (2007) reported that citrus fruit peel meal contains residual anti-nutritional substances such as limonene, oxalate, phytate which was found to inhibit growth in poultry, reduced palatability of food and increased excretion of cholesterol (Malinow *et al.,* 1987). Broiler chickens fed control diet had significantly best feed conversion ratio of 2.01 compared to the broiler chickens fed SOPM based diets with and without enzyme treatment. The broiler chickens fed control diet utilized the feed consumed to produce body tissue better than broiler chickens in other dietary groups. This may be attributed to the quality of the feed in terms of palatability, acceptability and nutrient utilisation. The values of daily weight gain and daily feed intake obtained for finisher broiler chickens fed SOPM with and without enzyme were below the expected minimum value of 35 g and 85 g respectively, reported by Aduku (2005) except the broiler chickens fed control diet that recorded 42.91 g and 86.53 g respectively. The total mortality recorded was 7 (i.e 2.78 % of the total number of birds) and it spread across the different dietary treatments except treatments 5 and 6 with no mortality. Mortality recorded however, was not associated with any traceable cause.

The haematological indices of broiler chickens fed control diet and graded levels of dietary SOPM with and without enzyme treatment are presented in Table 5. The results obtained in this study showed that

PCV, RBC, WBC and Hb did not significantly (P>0.05) differ across the dietary treatments. Significant (P<0.05) differences were observed in MCV, MCH, MCHC, lymphocytes, heterophil, eosinophil and monocytes across the dietary treatments. The values of PCV, RBC, WBC and Hb obtained in this study were within the normal range of 27.43 % - 37.30 % RBC, 1.97 x 10^{12}L – 3.75 - x 10^{12}L RBC, 3.98 x 10^{9}L - 10.82 x 10^{9}L WBC and 7.50 g/dl to 16.04 g/dl Hb reported by Talebi *et al.* (2005) who investigated a comparative study of haematological values of four different broilers strain (Ross, arbor acres, Cobb and Arian). Non significant (P>0.05) effect recorded in PVC, RBC, WBC and Hb may imply that the bone marrows of the birds were functioning normally which revealed the absence of macrocytic and hypochronic anaemia. It also showed that the processing technique which gave rise to SOPM may have reduced its anti-nutritional factors and improve its energy and protein content which according to Cary *et al.* (2002) improves broiler chicken performance. This also confirmed the fact that haematological traits, especially PCV and Hb were correlated with the nutritional status of the broiler chicken. MCH is an indicator of the blood carrying ability of the RBC and the result obtained could suggest that the birds on all the dietary treatments may be more efficient in performing respiratory function as observed by Longe and Fagbenro (1990). The significant (P<0.05) differences reported for MCH, MCV and MCHC across the dietary treatments were within the normal range for healthy broiler chickens as stated by Akinola and Etuk (2015) whose reported MCH values 24.4 pg – 57.2 pg, MCV value 111 fL – 144 fL, MCHC value 23.4 g/dL – 47.2 g/dL, lymphocyte value of 5.52 x 10^{10}/µL – 20.36 x 10^{10}/µL, monocytes value of 0.36 x 10^{10}/µL – 1.68 x 10^{10}/µL, eosinophil value of 0.6 x 10^{10}/µL – 1.71 x 10^{10}/µL and heterophil value of 47 % – 100 %, for broiler chickens. Significant effect reported on lymphocytes, heterophil, eosinophil and monocytes was in line with the findings of Owosibo *et al.* (2013). This observation indicated that the nutrients were adequately utilized by the broiler chickens and posed no problem to the birds. It explained why the birds were healthy, not anaemic and capable of withstanding stress. Serum biochemical indices of broiler chickens fed SOPM based diets are presented in Table 6. Significant differences (P<0.05) were observed for all the biochemical indices measured in this study. The values of total protein, albumin, globulin and uric acid recorded in the groups of broiler chickens fed dietary SOPM without enzyme treatment ranged from 4.46 to 4.66, 1.33 to 1.76, 2.80 to 3.06 and 3.30 to 4.03 g/dl, respectively. The significant similar values recorded on broiler chickens fed SOPM based diet and control diet implied that SOPM with or without enzyme can be confidently used in broiler chickens diet to provide optimum nutrition. The significant differences recorded in serum total protein, albumin, globulin and uric acid across all the dietary treatments showed that there was normal nutrients metabolism. It showed that the diets had better nutritional quality, good amino acid balance; thus, there was absence of muscle degeneration on birds. Imbalances in amino acid in diets had been found to cause elevated blood uric acid concentration (Oladunjoye *et al.,* 2014). The significant (P<0.05) differences recorded for albumin and globulin showed that there was no liver damage caused by toxicity of dietary substances. This was in line with the finding of Muhammad and

Oloyede (2009) who stated that the values of albumin and globulin are normally low in the blood but becomes high when there is occurrence of liver damage by toxic substances.

The production cost of finisher broiler chickens fed diets containing SOPM with and without enzyme treatment is summarized in Table 7. Feed cost (₦/kg) ranged between ₦135.19 to ₦156.48 and broiler chickens fed control diet recorded the highest value of ₦156.48/kg than broiler chickens fed SOPM based diets with and without enzyme treatment. This was attributed to high cost of maize (a conventional feed ingredient). The feed cost of broiler chickens in SOPM based diets progressively decreased with increased levels of dietary SOPM. This confirmed the findings of Ojabo *et al*. (2014); Ngiki *et al.* (2014) and Olaifa *et al.* (2015) that feed cost per weight gain decreased with increased dietary levels of sweet orange peel meal, cassava root-leaf meal mixture and cassava peel meal based diet respectively on broiler chickens. Broiler chickens fed 20 % dietary SOPM with and without enzyme treatment had the least value of feed consume per weight gain similar to the value recorded for the broiler chickens fed control diet. This was function of low feed consume which was efficiently utilized. The highest Feed cost per chick recorded for broiler chicks fed control diet was as a result of non-inclusion of SOPM as a replacement for maize which facilitated the palatability and acceptability of the feed for optimum consumption compared to the broiler chickens fed SOPM based diets with and without enzyme. This was similar to the observation of Ukachukwu (2008) and Akinfala *et al.* (2011) with cassava plant meal, though without enzyme supplementation. The broiler chicks fed control 1.73 kg - 1.98 kg. Selling price per broiler chicken was fixed at ₦650.00 per kilogram live weight. The highest income and expenses per bird was recorded on broiler chickens fed control diet. The analysis diet recorded the highest feed cost as the percentage of total cost, this was as a result of high cost of feed and total cost of production. The least cost of day old chick as percentage of total cost of production was recorded for broiler chickens fed control diet and was due to the highest total cost of production compared to the broiler chickens fed SOPM based diets with and without enzyme. Break-even analysis for finisher broiler chickens fed diets containing SOPM with and without enzyme treatment is showed in Table 8. The result showed that the highest profit amounting to ₦436.90 k was made on broiler chickens fed control diet compared to profit made on broiler chickens fed SOPM based diets with and without enzyme which ranged from ₦172.69 k – ₦259.44 k. The profit per bird decreased with increased levels of dietary SOPM with and without enzyme treatments. The highest income incurred on broiler chickens fed control diet resulted to better cost to benefit ratio compared to broiler chickens fed SOPM based diets with and without enzyme treatment, although, there was no record of loss as the profit was made at all SOPM inclusion levels.

Table 5: Effect of experimental diets on haematological indices of broiler finisher chickens

TRT	PCV (%)	RBC x10^9/l	WBC x10^9/l	Hb (g/dl)	MCV (fl)	MCH (Pg)	MCHC (g/dl)	Lymphocytes (%)	Heterophil (%)	Eosinophil (%)	Basophil (%)	Monocytes (%)
T_0	32.33	3.00	7.26	10.80	119.03^{ab}	39.76^{ab}	33.36^{ab}	30.66^{ab}	66.66^{ab}	1.33^{ab}	0.00	1.33^{c}
T_1	34.00	2.86	6.80	11.00	118.97^{ab}	38.53^{ab}	32.43^{b}	27.00^{ab}	68.00^{a}	2.00^{a}	0.00	2.33^{abc}
T_2	33.66	3.13	6.86	11.33	114.77^{ab}	38.66^{ab}	33.76^{a}	26.33^{ab}	67.66^{a}	1.33^{ab}	0.00	1.33^{c}
T_3	35.33	2.56	5.93	11.76	134.97^{ab}	46.86^{ab}	33.26^{ab}	32.66^{ab}	61.00^{ab}	0.33^{b}	0.00	2.66^{ab}
T_4	36.66	3.60	4.20	12.20	101.80^{b}	34.10^{b}	33.23^{ab}	27.66^{ab}	68.00^{a}	1.33^{ab}	0.00	3.00^{a}
T_5	36.66	2.43	5.40	12.20	157.27^{a}	52.46^{a}	33.23^{ab}	34.00^{a}	59.33^{b}	0.66^{ab}	0.00	1.66^{bc}
T_6	35.66	2.933	5.53	11.90	124.00^{ab}	42.16^{ab}	33.33^{ab}	24.66^{b}	65.33^{ab}	1.00^{ab}	0.00	2.33^{abc}
SEM	0.56^{ns}	0.15^{ns}	0.42^{ns}	0.18^{ns}	6.12*	2.01*	0.14*	1.21*	1.06*	0.17*	0.00^{ns}	0.18*

*^{a,b}Means within each row with different superscripts are significantly different (P< 0.05). ns - not significantly different (P>0.05); * significantly different (P<0.05) PCV – Pack Cell Volume; RBC – Red Blood Cell; WBC – white Blood Cell; Hb; Haemoglobin; MCV – Mean Corpuscular Volume; MCH – Mean Corpuscular Haemoglobin; MCHC; Mean Corpuscular Haemoglobin Concentration; SEM = standard error of mean. T_0 = Control diet (without SOPM and enzyme); T_1 = 15 % SOPM without enzyme; T_2 = 20 % SOPM without enzyme; T_3 = 25 % SOPM without enzyme; T_4 = 15 % SOPM with enzyme; T_5 = 20 % SOPM with enzyme; T_6 = 25 % SOPM with enzyme*

Table 6: Effect of experimental diets on broiler finisher chicken serum biochemical indices

Treatments	Total Protein (g/dl)	Albumin (g/dl)	Globulin (g/dl)	Uric acid (mg/dl)
T_0	5.30[a]	1.50[ab]	3.80[a]	2.90[b]
T_1	4.66[b]	1.60[ab]	3.06[bc]	3.30[ab]
T_2	4.56[b]	1.76[ab]	2.80[c]	4.03[a]
T_3	4.46[b]	1.33[b]	3.03[bc]	3.50[ab]
T_4	4.90[b]	1.53[ab]	3.36[b]	4.00[a]
T_5	4.50[b]	2.13[a]	2.36[c]	3.60[ab]
T_6	4.93[ab]	1.76[ab]	3.16[ab]	3.96[a]
SEM	2.18*	1.02*	1.22*	0.53*

*[a,b,c]Means within each row with different superscripts are significantly different (P< 0.05). * Significantly different (P<0.05); SEM = standard error of mean; T_0 = Control diet (without SOPM and enzyme); T_1 = 15 % SOPM without enzyme; T_2 = 20 % SOPM without enzyme; T_3 = 25 % SOPM without enzyme; T_4 = 15 % SOPM with enzyme; T_5 = 20 % SOPM with enzyme; T_6 = 25 % SOPM with enzyme*

Table 7: Production cost of finisher broiler chickens fed diets containing sweet orange peel meal with and without enzyme

Economic Indices	Experimental diets						
	T_0	T_1	T_2	T_3	T_4	T_5	T_6
C of DOC	110.00	110.00	110.00	110.00	110.00	110.00	110.00
FC/kg (₦)	156.48	143.71	139.45	135.19	144.51	140.25	135.99
FI/56d/kg	4.85	4.39	3.89	4.10	4.57	4.02	4.13
AWG/kg	2.40	1.94	1.72	1.72	1.94	1.76	1.68
FC/WG (₦/kg)	315.59	324.52	315.29	321.78	339.75	319.90	334.24
FC/chicks/ 56days/(₦)	758.93	630.89	542.46	554.28	660.41	563.81	561.64
OPC (₦)	280.17	280.17	280.17	280.17	280.17	280.17	280.17
TCP (₦/chick)	1147.10	1021.06	932.63	944.45	1050.58	953.96	951.81
CS due to SOPM (₦/chick)	-	128.04	216.47	204.65	98.52	195.12	197.29
FC (% TCP)	66.05	61.79	58.16	58.69	62.86	59.10	59.01
C of DOC (%TCP)	9.57	10.77	11.79	11.65	10.47	11.53	11.56

FFC = feed cost; CS = Cost savings; DOC = Day old chicks; C = Cost; TCP = Total cost of production; FC = Feed cost; FI = Feed intake; OP = Operational cost; WG = Weight gain; T_0 = Control diet (without SOPM and enzyme); T_1 = 15 % SOPM without enzyme; T_2 = 20 % SOPM without enzyme; T_3 = 25 % SOPM without enzyme; T_4 = 15 % SOPM with enzyme; T_5 = 20 % SOPM with enzyme; T_6 = 25 % SOPM with enzyme, SOPM = sweet orange peel meal

Table 8 : Break-even analysis for finisher broiler chickens fed diets containing sweet orange peel meal with and without enzyme

TRT	ALW (kg)	Selling price (₦)/kg/LW	Income /birds (₦)	Expenses/ birds (₦)	Profit/ bird (₦)/kg	CST:BFT (₦)
T_0	2.44	650.00	1586.00	1149.10	436.90	0.72
T_1	1.97	650.00	1280.50	1021.06	259.44	0.80
T_2	1.75	650.00	1137.50	932.63	204.87	0.82
T_3	1.75	650.00	1137.50	944.45	193.05	0.83
T_4	1.98	650.00	1287.00	1050.58	236.42	0.82
T_5	1.80	650.00	1170.00	953.96	216.04	0.82
T_6	1.73	650.00	1124.50	951.81	172.69	0.85

TRT = Treatment; CST: BFT = Cost to benefit ratio; ALW = Average live weight; LW = Live weight; T_0 = Control diet (without SOPM and enzyme); T_1 = 15 % SOPM without enzyme; T_2 = 20 % SOPM without enzyme; T_3 = 25 % SOPM without enzyme; T_4 = 15 % SOPM with enzyme; T_5 = 20 % SOPM with enzyme; T_6 = 25 % SOPM with enzyme

Conclusion

Sun-dried sweet orange peel meal can be used in the diet of broiler chickens up to 25 % without posing any deleterious effect on the broiler chickens growth performance, blood parameters and production cost. However, the cost to benefit ratio was compromised.

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