Use of sweet orange peel meal (SOPM) in broiler chicken diet with and without Polyzyme®

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Abstract

A study was conducted to evaluate the use of sweet orange peel meal (SOPM) in broiler chicken diet with and without polyzyme®. An 8 week feeding trial was carried out using day old Abor Acre plus strain of broiler chickens. Four groups of 36 birds each were fed two diets that contained 20 and 25 % sweet orange peel meal with or without Polyzyme® in a factorial design. Data were collected on growth performance, nutrient utilization, carcass characteristics and intestinal tract length. Significant ($p<0.05$) depression were observed in average final weight (1976.64 to 1775.76 g), average daily weight gain (34.69 to 31.10 g) and average daily feed intake (79.98 to 70.65 g) when sweet orange peel meal was increased from 20 to 25 % in the diets. This effect was reversed when enzyme was added in the diet. Except on crude protein; increasing the sweet orange peel meal from 20 to 25 % did not have significant ($P>0.05$) effect on feed utililization and mortality. Birds fed 25 % sweet orange peel meal had lower ($p<0.05$) live weight and crude protein utilization than those fed 20 % which were improved when enzyme was added. Gizzard weight and gastro-intestinal tract length of birds fed 25 % rice bran were higher ($p<0.05$). It was concluded that 20 sweet orange peel meal can be included in broiler diets but may be increased to 25% when polyzyme®is added.

Keywords: sweet orange peel meal, polyzyme®, finisher, broiler, growth

Introduction

The high cost of the conventional feedstuffs caused by the global economic crisis has affected animal production, especially the poultry industry, where the feeds represent between 58 to 70% of the total production cost (Sunmola, 2018). It has been reported that even with increasing production of grain maize, the price is still very high and not profitable for poultry industry (FAO, 2013). Therefore, there is need to seek alternative feeds for poultry, while maintaining product quality to compensate for the negative effects of its higher prices and lower consumption (Olmo *et al.*, 2012). Citrus by-products like sweet orange peel may be a nutritional and economical alternative for poultry feeding (Sunmola, 2018). Economically, orange is important fruit crop, with an estimated 75 million metric tons produced worldwide as at 2009 for a total value of over USD 12 billion. Of this total, half came from Brazil and the United States of America (Bernardi, 2010).

Nigeria is among the tenth citrus fruit producing countries in the world with about 3,900,000 tons of citrus fruits produced from an estimated hectarage of 800,000 hectares of land in 2012 (FAO, 2013). Major citrus producing states in Nigeria include Benue (Makurdi), Nassarawa, Kogi, Ogun, Oyo, Osun, Ebonyi, Kaduna, Taraba, Ekiti, Imo, Kwara, Edo, and Delta. The peel of sweet orange which is the outer cover (skin) of the sweet orange fruit can be sun-dried and milled in a grinding machine to fine particles to obtain the orange peel meal (Ipinloju, 2000). Orange peel contains a variety of nutrients such as phenolic compounds, ascorbic acid, coumarin, volatile oils (Fernández-López *et al.,* 2005) such as pinene (Azar *et al*., 2011), flavonoids such as hesperidin, ferulic acid, tangeretin, sinensetin, nobiletin (Malterud Luo *et al*., 2008), naringin and pectin. Naringin has been shown to reduce significantly the levels of total cholesterol, low density lipoprotein cholesterol (LHD), very low density lipoprotein cholesterol (VLDL) and triglycerides, but naringin did not decrease high density lipoprotein (HDL) in chickens (Malterud Luo *et al*., 2008). During orange juice production, great amounts of residue (peel, pulp, seeds, orange leaves) and whole orange fruits that do not meet the quality requirements are generated as waste (Rezzadori *et al*., 2012). This waste is generally available in large quantities during the citrus season and thus it causes an environmental problem since it does not have any productive use (Oluremi *et al*., 2007). Sweet orange peel has no direct nutritional value to man but it has high energy content that favourably compares with cereals which makes it a potential feed resource for poultry (Agu *et al*., 2010). Like other agro-industrial by-products however, its high fiber content limits its utilization by poultry (Oluremi *et al*., 2007). Our previous trial with broiler chickens showed that the meal of sun-dried sweet orange peels meal of *Citrus sinensis* could replace up to 15 % of dietary maize in broiler diet without any adverse effect on their performance (Agu *et al*., 2010).

The use of exogenous enzymes to improve the nutritional value of high fiber diets has been well documented (Angelovicova *et al*., 2005 and Raza *et al*., 2009) and has been shown to improve nutrient digestibility, destroy anti-nutritional factors and manipulate gut flora population as well as supplementing endogenous enzymes (Bedford and Cowieson, 2012). 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's recommended dosage of 400 gm per ton of mash feed. Therefore, this experiment was conducted to evaluate the use of sweet orange peel meal (SOPM) in broiler chicken diet with and without polyzyme® above the previously recommended level of 15 % with and without Polyzyme® treatment.

Materials and Methods

Experimental site

The study was conducted at the Poultry Unit of the Livestock Section, Teaching and Research Farm, Federal University of Agriculture, Makurdi, Benue State, Nigeria. Makurdi is located between latitude $7^0$44′N and longitude $8^0$21′E in the Guinea savanna zone of West Africa. The annual rainfall ranges between 6 to 8 months (March - October) and 508 to 1016 mm with average minimum temperature of 24.20 ± 1.4^{0}C and maximum temperature of 36.33 ± 3.70^{0}C. The relative humidity ranges between 39.50 ± 2.20% and 64.00 ± 4.80% (TAC, 2011).

Collection and preparation of test ingredients

About 1000 kg fresh sweet orange (*Citrus sinensis*) fruit peel (test ingredient) was collected immediately after peeling from orange retailers within the campus of Federal University of Agriculture, Makurdi, Benue State, Nigeria. The peel was sun-dried to moisture content of less than 12 % to prevent fermentation and other forms of deterioration. It was milled to obtain the sweet orange peel meal (SOPM) and mixed with other feed ingredients to produce the experimental diets.

Experimental birds and management

A deep litter poultry house was cleaned, fumigated, washed and disinfected with 1 % formalin solution prior to the arrival of the chicks. The feeders and drinkers were also disinfected 24 hours before the arrival of the broiler chicks. Disinfectant solution was prepared daily and poured in the foot dip at the entrance to the pen for disease control. Charcoal stoves were used to maintain the required temperature for brooding, and light was provided using 200-watt electric bulbs throughout the experiment. Vaccines (Gomboro and Lasota) were administered and other health management practices were observed according to the recommendation of the veterinary officer of Veterinary Teaching Hospital, Makurdi, Benue State, Nigeria.

Experimental diets and design

One hundred and forty four (144) unsexed day old *Abor Acre plus* broiler strain chicks purchased from Vertex Farms in Ibadan, Oyo State, Nigeria were used for this experiment. The birds were randomly distributed into four dietary treatments in a 2 x 2 factorial arrangement with two levels of polyzyme® (0 % and 0.04 %) and two levels of sun-dried sweet orange peel meal (20 % and 25 %) and each having three replicates with 12 chicks per replicate. All the diets were iso-nitrogenous and iso-caloric as shown in Table 1 and were formulated to meet standard nutrient requirements of broiler according to Aduku (1995) from day 1 to 28 (Starter phase) and from 29 to 56 (Finisher phase).

Table 1: Gross composition of the experimental diets

Levels of SOPM	Starter diets				Finisher diets			
(%)	20		25		20		25	
Treatments	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
White maize	42.08	42.08	38.45	38.45	46.73	46.73	44.00	44.00
SOPM	10.52	10.52	13.15	13.15	10.92	10.92	13.65	13.65
Soya bean meal	37.35	37.35	37.35	37.35	32.05	32.05	32.05	32.05
Rice bran	3.25	3.25	3.25	3.25	3.00	3.00	3.00	3.00
Blood meal	2.00	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	3.00
Palm oil	1.00	1.00	1.00	1.00	1.50	1.50	1.50	1.50
Herbo-Methionine	0.15	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	0.25
L-Lysine	0.20	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	0.20
Polyzyme®	+	-	+	-	+	-	+	-
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis								
**ME (Kcal/kg)	2888	2888	2864	2864	2955	2955	2943	2943
Crude protein (%)	23.82	23.82	22.93	22.93	21.06	21.06	21.02	21.02
Crude fibre (%)	5.19	5.19	5.77	5.77	5.24	5.24	5.53	5.53
Ether extract (%)	3.94	3.94	4.14	4.14	4.03	4.03	4.13	4.13
Lysine (%)	1.46	1.46	1.45	1.45	1.32	1.32	1.31	1.31
Methionine (%)	0.62	0.62	0.61	0.61	0.57	0.57	0.57	0.57
Calcium (%)	1.04	1.04	1.04	1.04	1.03	1.03	1.03	1.03
Available P (%)	0.87	0.87	0.84	0.84	0.84	0.84	0.83	0.83

*Premix provided 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.
**ME kcal/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;

Growth data collection

Data were collected weekly on feed intake, body weight and weight gain. Feed intake was calculated as quantity difference of feed given and leftover after 24 hours. Weight gain was determined as the difference in the weight of the birds after 56 days period. Feed: weight gain ratio was calculated as feed intake per weight gain.

Nutrient digestibility

Nutrient digestibility evaluation was done at the end of week seven (7) and terminated at the end of week eight. Two birds per replicate group were selected and transferred into metabolic cages. A 3-days acclimatization period was allowed for the birds and the respective diets were offered *ad-libitum*. Daily feed intake and daily faecal output were recorded for 4 days. The droppings were collected per replicate once daily at 8:00 am, weighed and dried in an oven at 70° C to constant weight. Dried excreta were bulked and ground. Experimental diets and feacal samples were used to determine their respective proximate constituent according to AOAC (2006), while the metabolizable energy was calculated using the equation; 37 x % CP + 81.1 x % EE + 35.5 x % NFE (Pauzenga, 1985).

Carcass evaluation

At the end of the experimental period, three (3) birds per treatment with body weight similar to the average for the treatment were selected and fasted for 12 hours to ensure the emptiness of the gastrointestinal tract of feed and later weighed to obtain live body weight according to standard procedure (Australian Chicken Meat Federation, 2013). They were slaughtered by a sharp knife for complete bleeding, immersed in hot water at about 85^{0}C for de-feathering. Feathers were plucked, head and shanks were removed; carcasses were left for 15-30 minutes for excess water to be drained and later cut into prime parts which were each weighed and expressed as percent carcass (dressed) weight as follows:

$$\text{Dressing percentage} = \frac{\text{Dressed carcass weight (g)}}{\text{Live body weight (g)}} \times 100$$

$$Carcass\ part\ (\%\ DW) = \frac{Cut\ Part\ (g)}{carcass\ weight\ (g)} \times 100$$

$$Internal\ organ = \frac{Organ\ (g)}{Live\ body\ weight\ (g)} \times 100$$

Statistical analysis

All generated data were subjected to 2 – way Analysis of Variance (ANOVA) using SAS (2008) software package and the means of the parameters which were significantly different (P<0.05) were separated using Duncan's Multiple Range Test (DMRT).

Results and Discussion

The proximate composition of sweet orange (Citrus sinensis) peel meal

The proximate composition and energy content of sweet orange peel meal and maize used in this study is presented in Table 2. 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, respectively.

The CP 8.20 % in the peels was lower than CP in maize, a conventional energy feedstuff with CP content of 9.10 %. The crude fibre of 13.30 % was higher than 1.30 % CF reported for maize (Aduku, 2005). The high CF in the peel may reduce its feeding value compared to conventional dietary maize in poultry nutrition. However, the energy contents of SOPM used in this study (3079.61 kcal/kg) and maize (3432 kcal/kg) were high. Therefore, SOPM can partially replace conventional maize in broiler chicken diets. Agu *et al.* (2010) reported 89.65 % DM, 10.73 % CP, 11.90 % ash, 12.60 % EE, 7.86 % CF, 56.91 % NFE and 3988.70 ME kcal/kg. The results of proximate composition of SOPM showed that it possesses some nutritional properties that can make it beneficial in broiler chicken diets with proper handling.

Effect of dietary SOPM with and without polyzyme® on performance of broiler chickens is presented in Table 3. All groups of broiler chicks had initial weight of between 33.53 – 33.65 g. The final body weight ranged from 1775.76 – 1976.64 g/bird. Feed conversion ratio (FCR) and mortality were not affected by the dietary treatment (P>0.005). This indicates that broiler chickens can tolerate up to 25 % sweet orange peel meal in their diets without any adverse effect on utilization and survivability. Dietary level of sweet orange peel meal however had significant (p<0.05) effect on the average final weight, average daily weight gain and average daily feed intake. Average final weight, average daily weight gain and average daily feed intake decreased (p<0.05) when sweet orange peel meal was increased from 20 % to 25 % level in the diet. This can be attributed to high fiber in sweet orange peel meal which probably reached a critical level at this inclusion level. According to Ayed *et al.* (2011), high crude fibre contained in the orange peel can precipitate negative effects on broiler chickens performance. McDonald *et al.* (1995) also reported that high dietary fibre level above 6 % may adversely affect the performance of the broiler chickens.

Table 2: Proximate composition and energy content of sweet orange (*Citrus sinensis*) peel meal and maize (% DM)

Nutrients (%)	Feedstuff	
	[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; ME = Metabolizable energy

Table 3: Effect of sweet orange peel meal and Polyzyme® on growth performance of broiler chickens

	AIW (g)	AFI (g)	AWG (g)	AFW (g)	FCR	MORT (%)
Level of SOPM (%)						
20	33.53	79.98[a]	34.69[a]	1976.64[a]	2.30	0.50
25	33.63	70.65[b]	31.10[b]	1775.76[b]	2.27	0.16
Level of Polyzyme®						
-	33.58	73.90[b]	32.70[b]	1865.28[b]	2.26	0.33
+	33.58	76.73[a]	33.09[a]	1887.12[a]	2.32	0.33
Interaction (SOPM x Polyzyme)	NS	*	*	*	NS	NS
SEM	0.03	1.68	0.71	39.76	0.02	0.18

[a,b] 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). Note: AIW = average initial weight; AFW = average final weight; AWG = average weight gain; AFI = average feed intake; FCR = feed conversion ratio; MORT = Mortality SEM = standard error of mean; SOPM – Sweet orange peel meal

Yang and Chung (1985), Agu *et al*. (2010) and Ani *et al*. (2015) observed significant decrease in average weight gain and final weight gain with increased levels of sweet orange fruit (*Citrus sinensis*) peel meal.

Interaction effects were observed between dietary level of sweet orange peel meal and addition of Polyzyme® on average final weight, average daily weight gain and average daily feed intake Table 4. Enzyme addition had no significant (P>0.05) effect on average final weight, average daily weight gain and average daily feed intake of the birds at 20 % sweet orange peel meal inclusion level with and without Polyzyme®. However, when sweet orange peel meal included up to 25 %, addition of Polyzyme® significantly improved the average final weight, average daily weight gain and average daily feed intake (P<0.05) compared to the group without Polyzyme®. Brenes *et al*. (1993) reported improvement in weight gain of chicks fed barley containing diets as a result of enzyme addition. Also, Choudhary *et al.* (2005) inferred that mesquite pods could replace maize up to 20 % in multienzyme supplemented broiler diet. This indicates that broiler chicken can tolerate up to 25% sweet orange peel meal in their diet thereby making the feeding of 25 % sweet orange peel meal an attractive option when the diet is supplemented with Polyzyme®.

Table 4: Interaction between sweet orange peel meal and Polyzyme® on growth performance of broiler chicken

SOPM levels (%)	20		25		
Polyzyme® levels (%)	-	+`	-	+	SEM
Parameters					
AFW (g)	1976.01[a]	1977.27[a]	1754.55[b]	1796.97[a]	38.16
AWG (g)	34.68[a]	34.71[a]	30.73[b]	31.48[a]	0.73
AFI (g)	78.34[a]	78.63[a]	69.47[b]	71.83[a]	1.80

[ab] Means followed by different superscripts within row are significantly different (p<0.05). AFW = average final weight; AWG = average weight gain; AFI = average feed intake; SEM = standard error of mean;

The effect of SOPM based diets treated with Polyzyme® on nutrients utilization by the broiler chickens is presented in Table 5. Significant (p<0.05) reductions was observed in the utilization of crude protein when sweet orange peel meal was increased from 20 % to 25 % inclusion level. Addition of Polyzyme® however improved the utilization of crude protein. This can be attributed to the enhancing effects of Polyzyme®. This is in line with the report of Khan *et al*. (2006). The improvement could be due to disruption of plant cell wall fraction in sweet orange peel meal by xylanase, phytase, cellulase, β – glucanase, pectinases, α – amylase, protease, α – galactosidase, β – galactosidase, lipase and mannanase in Polyzyme®, all of which are capable to digest complex carbohydrates. Dry matter, crude fibre, ether extract and nitrogen free extract were not significantly (P>0.05) affected by the diet. However, there was no significant (P>0.05) interaction between sweet orange peel meal and Polyzyme® across all the nutrients observed except crude protein which was significantly improved by the addition of polyzyme®.

The carcass characteristics, gizzard weight and intestinal length of birds fed different levels of sweet orange peel meal with or without Polyzyme® is presented in Table 6. Dietary treatments had no significant (p>0.05) effect on the dressed weight, thigh, breast and small intestine. Live weight of birds fed 25 % sweet orange peel meal was lower (p<0.05) than those fed 20 % sweet orange peel meal. This was an indication of poor feed utilization (Uchegbu *et al*., 2004) occasioned by high fiber in this diet. This effect was reversed by addition of Polyzyme® possibly as a result of enhancement of fiber digestion by this enzyme. Abdominal fat was not observed at 25 % sweet orange peel meal inclusion in the diets. This can be attributed to high fiber in the diet. Hill and Dansky (1954) also noted that body fat content of chicken reduced when 40 % oat hull was included in their diet. Meanwhile, addition of Polyzyme® significantly (P<0.05) increased the abdominal fat. The higher abdominal fat that was observed in the birds with addition of Polyzyme® could be of health concern as fat has been implicated in heart diseases. Gizzard weight, weights of large intestine and caecum were however increased significantly (p<0.05) at 25 % sweet orange peel meal inclusion level. This can be attributed to high fiber in this diet (Kenneth, 1981). Similar increase was observed in the gizzard weight and intestinal length of birds fed high fiber diet based on cassava leaf meal (Borin *et al.*, 2006). Addition of Polyzyme® significantly (P<0.05) decreased gizzard weight while caecum length was increased.

Table 5: Effect of experimental diets on nutrients digestibility of broiler chickens

Dietary treatments	Dry matter	Crude protein	Crude fibre	Ether extract	NFE
Level of SOPM (%)					
20	72.43	70.52[a]	56.02	71.63	75.79
25	69.84	62.86[b]	55.11	68.04	72.73
Level of Polyzyme®					
-	69.32	66.13[b]	58.37	71.85	73.08
+	72.95	69.25[a]	52.76	67.85	75.50
Interaction (SOPM x Polyzyme)	NS	*	NS	NS	NS
SEM	1.14	1.49	2.25	1.88	1.11

[ab] Means followed by different superscripts within column are significantly different (p<0.05). NFE = Nitrogen free extract; SEM = standard error of mean; SOPM = sweet orange peel meal

There was interaction effect between sweet orange peel meal and Polyzyme® on live weight, abdominal fat, gizzard weight and caecum length.

Table 6: Effect of sweet orange peel meal and Polyzyme® on carcass characteristics, gizzard and intestinal weight of broiler chickens

Dietary treatments	Live wt (g)	Dressing (%)	Thigh (% DW)	Breast (% DW)	Abdominal fat (% LW)	Gizzard (% LW)	Small intestine (% LW)	Large intestine (% LW)	Caecum (% LW)
Level of SOPM (%)									
20	1936.67[a]	68.30	14.52	33.71	0.21[a]	2.81[b]	18.34	1.01[b]	2.97[b]
25	1666.67[b]	66.81	14.43	33.48	0.00[b]	3.14[a]	18.49	1.17[a]	3.24[a]
Level of Polyzyme®									
-	1791.67[b]	68.78	14.99	33.10	0.00[b]	3.05[a]	17.11	1.11	2.97[b]
+	1811.67[a]	66.33	13.99	34.09	0.21[a]	2.91[b]	19.72	1.06	3.23[a]
Interaction (SOPM xPolyzyme)	*	NS	NS	NS	*	*	NS	NS	*
SEM	49.18	0.69	0.26	0.34	0.05	0.10	0.67	0.03	0.15

[ab] Means followed by different superscripts within column are significantly different (p<0.05). SOPM – sweet orange peel meal; Wt – weight; LW – Live weight; DW – Dressed weight; SEM = standard error of mea

Conclusion

The result of proximate composition of sweet orange peel meal (SOPM) showed that it possesses some nutritional properties that can make it an attractive feedstuff in broiler chicken diets with proper handling; therefore, it can be included at 20 % in broiler chickens diets and may be increased up to 25 % when supplemented with Polyzyme®.

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