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Effects of Enzyme Supplementation on the Utilization of Sweet Potato (Ipomoea batatas) Meal Based Diets by Broiler Chickens

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Abstract
A feeding trial was conducted to determine the effects and optimum levels of replacing maize with sun-dried sweet potato meal supplemented with a multi-enzyme (SDSPM+EZ) in broiler chicken diets. Four isonitrogenous and isocaloric broiler starter and finisher diets were formulated to replace maize at graded levels of 0, 25, 50 and 75 percent. The starter and finisher diets were fed to three replicate groups of birds for four weeks during each phase. Eighteen and fifteen chicks per replicate were assigned during the two phases respectively in a complete randomized design. In the first phase, chicks fed 25% SDSPM+EZ diet had significantly the best ($P<0.05$) final body weight (786.80g), daily weight gain (26.71g) and FCR (2.27). Performance was also better for the 50% SDSPM+EZ treatment compared to the control group. There were no significant differences in the feed consumption of the birds with up to 50% SDSPM+EZ replacement of maize. Feed cost (₦/kg gain) for birds on all SDSPM+EZ diets were lower than for the control group. During the finisher phase, final body weight, daily weight gain, FCR and feed cost (₦/kg gain) improved significantly with increasing level of SDSPM+EZ up to 50% maize repl**a**cement. At 75% SDSPM+EZ performance was adversely affected. Weight of carcass and breast cut were significantly higher for the 50% and 25% SDSPM+EZ treatment groups. Trend analysis gave optimum replacement levels of 37.5% and 52.50% SDSPM+EZ for maize in starter and finisher diets. It was concluded that up to 50% of maize in broiler chicken diets can be replaced by SDSPM+EZ with satisfactory performance.
Keywords: Broiler chicken, Maize, Multi-enzyme, Sun-dried sweet potato meal, Optimum levels

1.0 Introduction

Animal protein is an essential component of a balanced diet. It is however, beyond the reach of many people in the developing countries mainly due to the high cost of animal products like meat and eggs. High cost of poultry products is attributed to the high cost of feeds which according to Ogundipe *et al.* (2003) accounts for 60-80% of poultry production cost. The poultry industry over the years depends mainly on maize as the source of energy in feeds. Energy sources such as sorghum and maize were reported by Okereke (2012) to constitute the bulk (50% to 55%) of the formulated poultry diets. High demand of maize for human consumption and industrial uses coupled with its fluctuating price contribute significantly to the high cost of feed and poultry products. Nutritionists therefore, continue to search for non- conventional, readily available and cost effective alternatives to maize.

Sweet potato (*Ipomea batatas)* is a cheaper root crop that has less competition with human and was reported to yield more calories per hectare than maize (Mwangi, 2011). Sweet potato is a good source of energy with carbohydrate accounting for 80% to 90% of the dry matter and starch is the main (75% DM) component of the carbohydrate (Dominguez, 1990). Woolfe (1992) also reported that sweet potato and maize have comparable metabolizable energy of 14.8 and 14.5MJ/kg respectively. In most studies carried out with sweet potato (SPM) meal in poultry diets, there were general trends of depressing performance with increasing level of SPM (Agwunobi, 1999; Maphosa *et al.,* 2003; Ayuk and Essien, 2009; Afolayan, 2010). The poor performances were associated with the anti-nutritional factors (ANFs) in the sweet potato. According to Aina and Fanimo (1997) sweet potato contains tannin, phytate, oxalate and trypsin inhibitors which may affect nutrient utilization and depress performance. Addition of exogenous enzymes was reported to inactivate ANFs, improve digestion and enhance nutrients utilization of some feedstuffs (Bedford,1996; Samarasinghe and Wenk, 2000; Meng and Slominski,2005). There is however limited information on the use of exogenous enzyme with sweet potato meal diets. Enzyme supplementation of sweet potato meal-based diets may also deactivate or reduce the ANFs in sweet potato meal and enhance its utilization as a poultry feed ingredient. Considering that sweet potato is cheaper than maize, its inclusion at high levels in broiler chicken diets may lower feed cost and increase availability of poultry meat for human consumption.

The main objective of this study was therefore, to evaluate the effects of enzyme supplementation of sun-dried sweet potato meal as a replacement for maize in broiler chicken diets.

2.0 Materials and Methods

2.1 Experimental Site

The study was conducted on a research farm at Gwagwalada, Abuja (latitude 8^0 55’22” and 9^0 14’ 34” N and longitude 6^0 51' 36"and 7^0 11' 35" E at an altitude of 210 m) Nigeria. The temperature of the area ranges between 30^0C-37^0C and rainfall is approximately 1650 mm per annum (Balogun,2001). Relative humidity is between 25%-45% and 50%-89% in the dry and wet season respectively (Climate-Data.Org,2015).

2.2 Source and preparation of the test material

Fresh white-skinned sweet potato tubers were purchased from Gwagwalada market Abuja. The unpeeled tubers were washed and sliced into chips of about 4 cm in length and 2 cm thickness. They were spread thinly on a clean concrete floor and sun-dried for three days until they became brittle. Drying was done in the months of March and April when average daily temperature was 30^0C-30.1^0C (Climate Data.Org, 2015). The dried chips were milled to form sun-dried sweet potato meal for incorporation into diets.

2.3 Experimental Diets

Four broiler starter and finisher diets were formulated with sundried sweet potato meal and maxigrain multi-enzyme at the rate of 15g of the enzyme per 100 kg diet. Each gram of maxigrain contains cellulase (10,000 IU), xylanase (10,000 IU), protease 4000 IU and phytase (2500 FTU).

- Cellulase: breaks down cell wall to release locked nutrients
- Xylanase: degrade Non-Starch Polysaccharide (NSP) in the feeds
- Phytase: digest phytates to liberate Phosphorus (P) and other bound minerals.
- Protease: acts on protein to liberate peptides and amino acids.

The sundried sweet potato meal supplemented with multi-enzyme was included at graded levels of 0, 25, 50 and 75 percent maize replacement (Tables1and 2). All the diets were isonitrogenous and isocaloric.

2.4 Experimental design and management of the birds

Two hundred and sixteen, day-old broiler chicks (Arbor Acre) were balanced for weight and randomly assigned to the four dietary treatments. There were three replicates for each treatment with 18 birds per replicate in a completely randomized design. The birds were raised in deep litter pens. During brooding, each pen was fitted with 100watt electric bulb and additional warmth was provided with regulated kerosene stoves arranged along. the passage. The birds were on the experimental starter diets for four weeks followed by one week on a common diet. At the finisher phase, 180 five-week old birds of approximately equal pen weight were allocated to the four SDSPM+EZ finisher diets. There were three replicates with 15 birds in each replicate. The finisher phase lasted from 5-9 weeks. In both starter and finisher phases feed and water were provided *ad libitum.* The birds were duly dewormed and vaccinated against gumboro and newcastle. Weight of the birds and feed consumption records were kept on weekly basis, FCR and feed cost/kg weight gain were also calculated weekly while mortality was recorded as it occurred.

2.5 Carcass analysis

At nine weeks three birds per replicate of average pen weight were weighed and starved overnight to minimize faecal contamination during evisceration. The birds were weighed again to obtain the fasting live weight. They were slaughtered, bled, scalded in hot water, de-feathered and eviscerated. The head, neck, shanks and visceral organs were removed to get the dressed weight. Prime cut-up parts (breast, back, drum sticks, wings, thighs) and internal organs were weighed using sensitive electronic scale. The values were expressed as percentage of the dressed and live weight respectively. The intestines were straightened and their lengths were measured by placing a thread along the length of each and subsequently measured over a tape rule.

2.6 Data analysis

The data obtained from the experiment were subjected to analysis of variance (ANOVA) using the general linear model of statistical analysis system (SAS, 2002) software. The means were separated using Duncan's Multiple Range Test (Duncan,1995). Trend analysis was carried out to determine the optimum levels of SDSPM+EZ that can replace maize in broiler starter and finisher diets.

Table 1: Composition of broiler starter diets containing graded levels of sun-dried sweet potato meal supplemented with a multi-enzyme (0-4 weeks)

	Level of SDSPM+EZ (%)			
Ingredients	0	25	50	75
Maize	53.91	40.43	27.00	13.48
Sweet potato meal	0.00	11.45	22.89	34.34
Blood	3.00	3.00	3.00	3.00
G/cake	26.38	27.72	9.05	30.42
Soya cake	7.50	7.50	7.50	7.50
Fish meal	3.00	3.00	3.00	3.00
Soya oil	1.45	2.14	2.80	3.50
Limestone	0.50	0.50	0.50	0.50
Bone meal	3.30	3.30	3.30	3.30
Salt	0.30	0.30	0.30	0.30
VTM premix	0.25	0.25	0.25	0.25
DL-methionine	0.25	0.25	0.25	0.25
Lysine	0.16	0.16	0.16	0.16
Enzyme	0.00	0.015	0.015	0.015
Total	100.00	100.00	100.00	100.00
Calculated analysis				
ME Kcal/kg	2960.36	2960.68	2960.00	2960.75
Crude Protein %	23.11	23.09	23.08	23.08
Crude Fibre %	4.89	4.50	4.58	4.42
Ether Extract %	5.98	6.63	6.72	7.12
Calcium %	1.29	1.30	1.32	1.33
Available P %	0.56	0.53	0.56	0.55
Lysine %	1.27	1.28	1.29	1.30
Methionine %	0.62	0.57	0.55	0.50
Feed cost (₦/kg)	101.86	99.51	97.21	94.41

*Bio- mix premix: starter, supplied/kg: Vit.A=10,000IU, Vit.D3=2000IU, Vit.E=23000mg, Vit.K=32000mg, Vit.B1 = 800mg,Vit.B2=5500mg, Niacin = 27,500mg, Pantothenic Acid = 7500mg, Vit.B6=3000mg, Vit.B12=15mg, Folic Acid = 750mg, Biotin H2 = 60mg, Choline chloride=300000mg, cobalt=200mg, Copper= 3000mg, iodine=1000mg, Iron=20000mg, Manganese=40000mg, Zinc=30000mg, Selenium=200mg, Anti-oxidant= 1250mg.

Table 2: Composition of broiler finisher diets containing graded levels of sun-dried sweet Potato meal supplemented with a multi-enzyme (5– 9 weeks)

	Level of SDSPM+EZ (%)			
Ingredients	0	25	50	75
Maize	57.81	43.37	28.91	14.45
Sweet potato meal	0	12.77	25.58	38.39
Blood meal	3.00	3.00	3.00	3.00
G/cake	23.17	24.55	25.91	27.28
Soya cake	6.00	6.00	6.00	6.00
Fish meal	2.50	2.50	2.50	2.50
Soya oil	2.82	3.10	3.39	3.67
Limestone	0.80	0.80	0.80	0.80
Bone meal	3.00	3.00	3.00	3.00
Salt	0.30	0.30	0.30	0.30
VTM premix	0.25	0.25	0.25	0.25
DL-methionine	0.21	0.21	0.21	0.21
Lysine	0.15	0.15	0.15	0.15
Enzyme	0.00	0.015	0.015	0.015
Total	100.00	100.00	100.00	100.00
Calculated analysis				
ME Kcal/kg	2992.52	2992.70	2992.75	2992.81
Crude Protein %	21.54	21.48	21.51	21.49
Crude Fibre %	3.19	3.26	3.30	3.42
Ether Extract %	6.39	6.46	6.59	8.00
Calcium %	1.27	1.31	1.32	1.34
Available P %	0.59	0.54	0.55	0.55
Lysine %	1.15	1.16	1.17	1.18
Methionine %	0.58	0.57	0.56	0.56
Feed cost (₦/kg)	99.64	98.27	96.07	93.83

Bio-mix premix finisher supplied/kg: Vit.A=8500IU, Vit.D3=1500IU, Vit.E=10000mg, Vit.K3=2000mg, Vit.B1=1500mg, Vit.B2=1600mg, Niacin=4000mg, Pantothenic Acid=20000mg, Vit.B6=5000mg, Vit.B12=1500mg, Folic Acid=10mg, Biotin H2=500mg, Choline chloride=175000mg, Cobalt=200mg, Copper=3000mg, iodine=1000mg, Iron= 20000mg, Manganese=40000mg, Zinc=30000mg, Selenium=200mg, Anti-oxidant= 1250mg.

3.0 Results and Discussion

Table 3: Performance of broiler chickens fed graded levels of sweet potato meal diets supplemented with a multi-enzyme (0-4 weeks)

	LEVELS OF SDSPM+EZ (%)				
Parameters	0	25	50	75	SEM
Initial Weight (g/bird)	39.00	39.00	39.00	39.00	0.00
Final Weight (g/bird)	720.66^{c}	786.80^{a}	747.95^{b}	37.33^{d}	7.77
Total Weight gain(g/bird)	681.66^{c}	747.80^{a}	708.95^{b}	598.33^{d}	7.10
Daily weight gain (g/bird)	24.35^{c}	26.71^{a}	25.32^{b}	21.37^{d}	0.06
Total Feed Intake (g/bird)	1664.11^{a}	1698.48^{a}	1672.16^{a}	1542.52^{b}	28.09
Daily feed intake (g/bird)	59.43^{a}	60.66^{a}	59.72^{a}	55.09^{b}	1.12
F C R	2.44^{c}	2.27^{a}	2.36^{b}	2.58^{d}	0.03
Feed cost (₦/kg gain)	248.54^{c}	225.89^{a}	229.42^{a}	243.58^{b}	1.82
Mortality (%)	1.90^{b}	0.00^{a}	1.90^{b}	0.00^{a}	0.55

a,b,c = means on the same row with different superscripts are significantly different, ($p<0.05$), SEM = standard error of the means, SDSPM+EZ = sundried sweet potato meal supplemented with multi-enzyme=FCR feed conversion ratio.

3.1 Growth Performance

Performance of chicks during the starter phase (Table 3) shows that final weight, total weight gain, average daily weight gain and Feed Conversion Ratio (FCR) of 25% SDSPM+EZ treatment group were the best ($P<0.05$) followed by those of the 50% treatment. This disagree with the observation of Maphosa *et al.* (2003). The improvement in weight and FCR at 25% and 50% of maize replacement levels could be attributed to the effects of the enzyme. The enzyme could have reduced the ANFs, enhanced digestibility and nutrients utilization for the improved growth. There were no significant differences in the feed consumption of birds fed 25% and 50% SDSPM+EZ diets with the control group ($P>0.05$). Poor performance was obtained from birds fed 75% SDSPM+EZ diet ($P<0.05$).

From these results, up to 50% of maize in the broiler starter diet can be replaced by SDSPM+EZ without adverse effects. Trend analysis however, indicated the optimum levels of weight gain and FCR to be 37.5% SDSPM+EZ replacement of maize (Figures 1 and 2). Feed cost per kg weight gain for birds fed SDSPM+EZ diets were significantly lower ($P<0.05$) than that of the control group. This agrees with the reports of Tewe *et al*. (2003) and Ayuk (2004). Feed cost of chicks fed 25% and 50% SDSPM+EZ diets were however, lower ($P<0.05$) than that of the 75% group. Poor feed efficiency due to higher quantities of residual ANFs may have resulted in the higher FCR observed with SDSPM+EZ replacement of 75% dietary maize. Consequently, this translated to a higher feed cost compared to the lower levels of SDSPM+EZ in the diets.

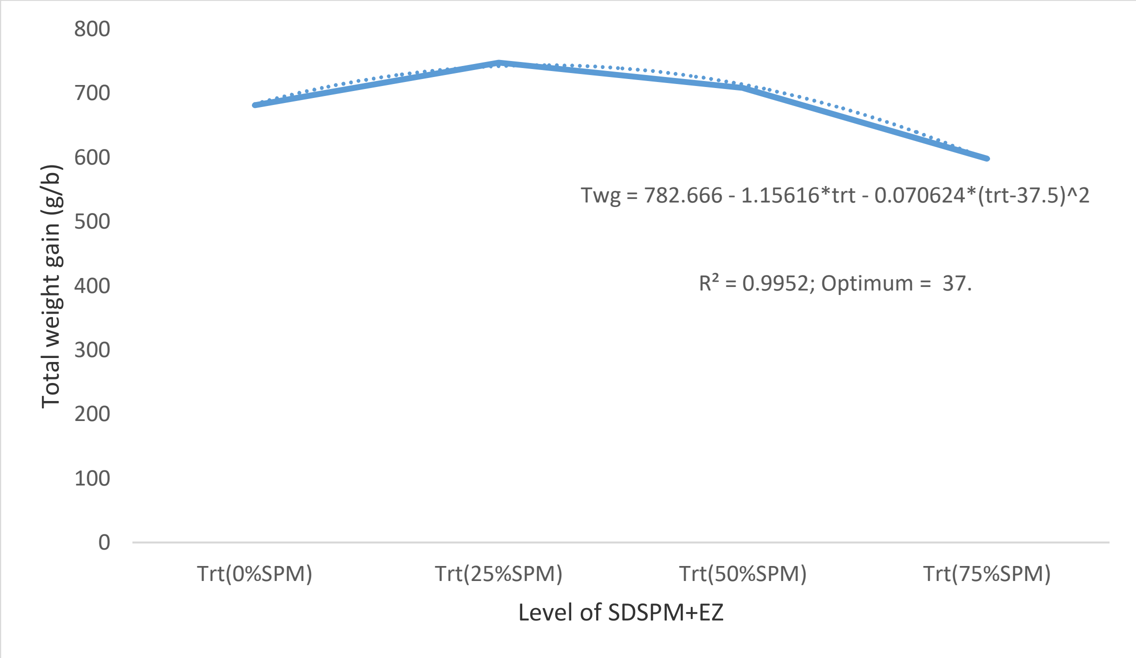


Figure 1: Trend of Weight Gain with the Dietary Level of SDSPM+EZ in Broiler Starter

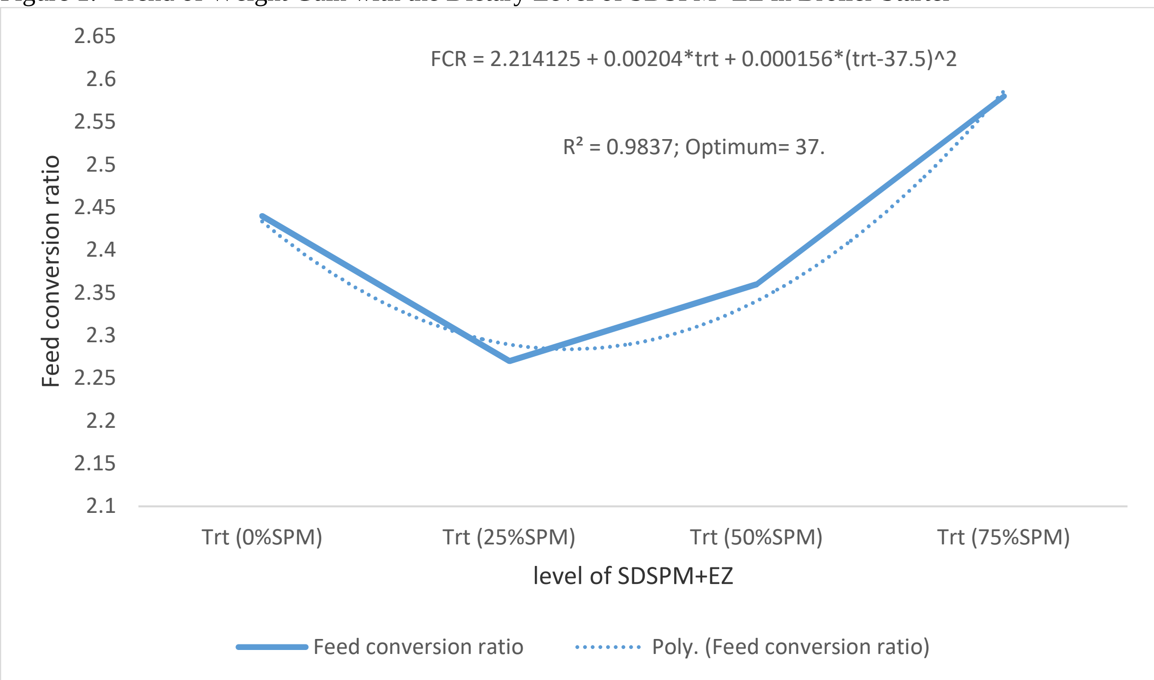


Figure 2: Trend of Feed Conversion Ratio with the Dietary Level of SDSPM+EZ in Broiler starter

In the finisher phase (Table 4), There was increase ($P<0.05$) in body weight, total weight gain, average daily weight gain and improved FCR with increasing level of SDSPM+EZ up to 50% level of maize replacement. At 75% replacement level, these parameters were adversely affected ($P<0.05$). Graphs of weight gain and FCR from regression analysis are curvilinear (Figures 3 and 4). Optimum levels of these parameters were indicated to be at 52.5% and 50% SDSPM+EZ replacement of maize respectively. The improvement in performance with up to 50% SDSPM+EZ level disagree with the reports of Maphosa *et al. (*2003) and Ayuk and Essien (2009) who observed decrease in weight gain and poorer FCR as level of dietary SPM increased. The superior growth performance obtained in this study with increasing level of SDSPM+EZ could be attributed to reduction in the levels of ANFs and enhanced digestion brought about by enzyme action. Feed intake was not significantly affected ($P>0.05$) with up to 50% SDSPM+EZ replacement of maize. Presence of higher concentration of residual ANFs and poly-molecules which could not be overcome by enzyme action could have reduced digestibility and feed intake observed at the 75% SDSPM+EZ level of inclusion.

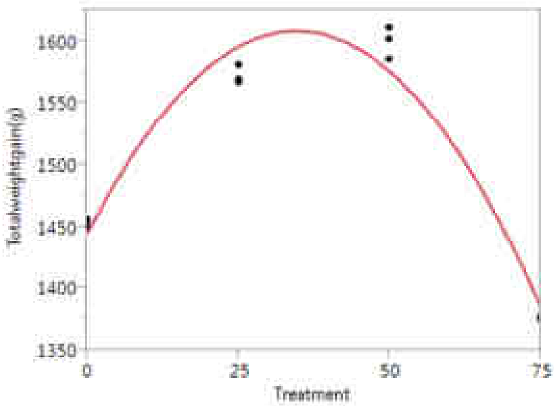
Table 4: Performance of broiler chickens fed graded levels of sun-dried sweet potato meal diets supplemented

with a multi-enzyme (5-9 weeks)

	Levels of SDSPM+EZ (%)				
Parameters	0	25	50	75	SEM
Initial Weight (g/bird)	1002.52	1002.60	1002.40	1002.40	0.18
Final Weight (g/bird)	2456.29[c]	2575.65[b]	2602.12[a]	2379.12[d]	11.58
Total Weight gain (g/bird)	1453.77[c]	1573.05[b]	1599.72[a]	1376.72[d]	8.32
Daily weight gain (g/bird)	51.92[c]	56.18[b]	57.13[a]	49.17[d]	0.26
Total Feed Intake (g/bird)	4300.00[a]	4305.58[a]	4312.13[a]	4178.98[b]	56.44
Daily feed intake (g/bird)	153.57[a]	153.77[a]	154.00[a]	149.32[b]	0.41
F C R	2.96[c]	2.74[b]	2.70[a]	3.04[d]	0.01
Feed cost (₦/kg gain)	294.93[d]	269.26[b]	259.39[a]	285.24[c]	2.09
Mortality (%)	4.44[b]	2.22[a]	4.44[b]	2.22[a]	0.04

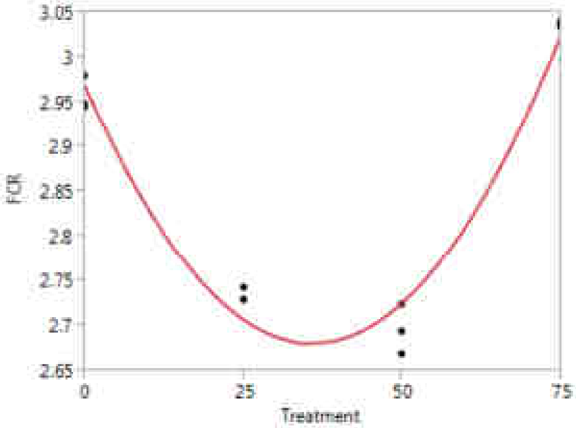
a,b,c = means on the same row with different superscripts are significantly different, (P<0.05), SEM = standard error of the means, SDSPM+EZ = sundried sweet potato meal supplemented with multi-enzyme=FCR feed conversion ratio.

Feed cost (₦/kg weight) reduced significantly (P<0.05) with increase in the level of SDSPM+EZ up to 50% level. The control group had the highest ((₦294.93) feed cost. Lowest feed cost (₦263.09) was obtained at 50% SDSPM+EZ followed by ₦272.47 for the 25% level. This could be due to the lower cost of sweet potato. The price of sweet potato as at the time of this feeding trial was ₦35.00 per kg compared to ₦70.50 for maize. Enzyme supplementation could have also improved feed utilization which enabled the birds to gain more weight at relatively lower feed costs.



Totalweightgain = 1638.4437 - 0.8178667*Treatment - 0.1369093*(Treatment-52.5)^2

Figure 3: Trend of Weight Gain with Dietary Level of SDSPM+EZ in Broiler Finisher Chickens



FCR = 2.6517291 + 0.0007791*Treatment + 0.000225*(Treatment-50)^2

Figure 4: Trend of feed conversion ratio with Dietary Level of SDSPM+EZ in Broiler Finisher Chickens

Mortality was low in this study and had no apparent association with the SDSPM+EZ dietary treatment. This is in agreement with the findings of Tewe *et al.* (2003). It is however, contrary to that of Maphosa *et al.* (2003) who found increase in mortality with increasing level of SPM inclusion in the diet.

3.2 Carcass characteristics and organs weight

Carcass weight and weight of breast cut were significantly increased (P<0.05) by substituting 25% and 50% maize with SDSPM+EZ (Table 5). Dressing percentage was not affected (P>0.05) by various SDSPM+EZ levels. This agrees with the observation of Beckford and Bartlett (2015). Tewe (2001) however observed lower carcass weight with SPM test diets relative to the control as against higher carcass yield obtained with 25% and 50% maize replacement in this study. The improvement in carcass weight is a reflection of the final body weight. This in turn could be attributed to better efficiency of feed utilization resulting from the enzyme action. There were no significant differences (P>0.05) in relative weights of most cut-up parts and visceral organs. Length of intestine was significantly lower and weight of abdominal fat was higher for the control group (P<.05). Intestinal length increased slightly while abdominal fat decreased with increase in dietary SDSPM+EZ level. The slight increase in the intestinal length with increase in dietary level of SDSPM+EZ is consistent with the observation of Afolayan (2010). It is however, contrary to the report of Maphosa *et al.* (2003) who found decrease in length of intestine as dietary SPM level increased. The lower weight of abdominal fat obtained with SPM diets in this study suggests that sweet potato meal could be a good feed ingredient for raising broiler chickens with higher quantity of lean meat.

Table 5: Carcass characteristics and organs weight of broiler chickens fed graded levels of sweet potato meal supplemented with a multi-enzyme

	Levels of SDSPM+EZ				
Parameters	0%	25%	50%	75%	SEM
Live weight (g/bird)	2382.60^{b}	2498.41^{a}	2524.06^{a}	2307.75^{c}	25.14
Dressed Weight (g/bird)	1710.79^{b}	1791.61^{a}	1800.41^{a}	1614.73^{c}	21.36
Dressing (%)	71.80	71.71	71.33	69.97	1.62
Drum sticks	16.57^{ab}	17.94^{ab}	18.45^{a}	16.40^{b}	1.0 2
Breast (%)	29.41^{b}	30.67^{a}	30.80^{a}	29.51^{b}	0.35
Wings (%)	13.22	12.92	13.34	12.88	0.24
Thighs (%)	21.75	21.90	21.98	21.56	0.29
Back cut	24.22	2410	24.50	24.12	0.24
Neck (%)	7.28	7.40	7.35	7.32	1.02
Liver (%)	2.22	2.31	2.25	2.12	1.11
Gizzard (%)	2.40	2.40	2.41	2.42	0.2
Heart (%)	0.48	0.52	0.48	0.50	0.11
Pancreas (%)	0.22	0.22	0.25	0.22	0.5
Small intestine (%)	3.12	3.01	3.18	3.06	1.05
Length of Small intestine (cm)	205.30^{b}	218.93^{a}	224.20^{a}	228.05^{a}	6.16
Abdominal fat (%)	2.00^{a}	1.90^{b}	1.82^{bc}	1.79^{c}	0.04
Crop (%)	0.10	0.10	0.11	0.10	0.01
Proventriculus (%)	0.21	0.20	0.23	0.20	0.02
Length of large intestine (cm)	33.34^{b}	34.40^{b}	35.67^{a}	35.47^{a}	0.42

a,b.c = means on the same row with different superscripts were significantly different, SEM = standard error of the means, SDSPM +EZ = Sundried sweet potato meal supplemented with multi-enzyme

4.0 Conclusion

Based on the superior growth performance, higher carcass weight and lower feed cost per Kg weight obtained with 25% and 50% SDSPM+EZ replacement of maize in this study, it was concluded that sun-dried sweet potato meal supplemented with a multi-enzyme can replace 50% of maize in broiler chicken diets with satisfactory performances.

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