Performance of broiler chickens fed maize-based diets substituted with graded levels of sweet potato meal

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Abstract

The performance of Ross broiler chickens fed on Sweet Potato Meal (SPM) as a dietary source of energy was studied. The study was carried out at both starter (0 – 4 wks) and finisher (5 – 9wks) phases. In both phases, SPM was incorporated at graded levels of 0, 10, 20, 30, 40 and 50 percent and dietary proteins were adjusted to make the diets iso-nitrogenous. In the starter phase, three replicates of 15 birds each were randomly allocated to each of the 6 treatments in a completely randomized design (CRD) experiment while the number of birds per replicate was reduced to 14 for the finisher phase using the same experimental design. Parameters measured or calculated include feed intake, body weight gain, feed efficiency, feed costs, feed cost/kg weight gain, mortality and carcass characteristics. The results showed similar trends in both phases. Differences in the feed intake were not significant (P>0.05) while weight gain, feed costkg^{-1} weight gain and total cost of rearing the birds decreased significantly (P<0.05). The Control, 10%, 20% and 30% SPM diets gave similar weight gain and feed:gain ratio. The Control gave the best performance in both starter and finisher phases, although its performance was not significantly different (P>0.05) from that of the 30%SPM diet Sweet Potato Meal level had no adverse effects on mortality and carcass characteristics. It is therefore concluded from this study that SPM should not be included beyond 30% level in a maize-based diet when protein requirement of birds is satisfied.

Key words: Sweet potato meal, broiler chicken, iso-nitrogenous diets, feed cost, feed efficiency.

Introduction

Nigeria, like other developing countries with all the potential to become self sufficient in food production still finds it difficult to feed her citizens adequately. All efforts to increase arable crop production to a level that can satisfy both animal and human needs have not yielded appreciable results. The main problem confronting livestock producers in Nigeria today is the unavailability and high cost of the conventional feed ingredients. The increasing demands for feed ingredients as industrial raw materials is not only aggravating the poor situation but pushing the market prices of the conventional feed ingredients to alarming heights (Sobamiwa, 1998). Nevertheless, the need to provide sufficient animal protein for the growing human population is of paramount importance to animal scientists.

Poultry has been identified as the fastest means of bridging the protein deficiency gap prevailing in most tropical countries like Nigeria (FAO, 1990). Presently, maize appears to be the major ingredient being used in feed formulation as a source of energy. It is being used by man and animals as food. Thus, there exists a strong competition between human and animals for maize. This competition has led to a soaring cost of maize, which is now a major source of instability in the poultry industry today. The inability to produce maize to a level that can satisfy its demand by both man and animals has led to a search for unconventional energy feed sources which can be more cost effective than maize. Such alternatives if found would reduce the present pressure on maize and subsequently lead to a reduction in the cost of feeding poultry.

Attempts to tackle poultry feed problems have led to the exploration of some affordable alternative energy feed sources. Some agro-industrial by-products like corn bran (Cresswell and Zainuddin (1980), maize offals (Atteh *et al.,* 1993, Vantsawa, 2001), rice offals (Dafwang and Shwarmen,1996), wheat bran and brewers dried grain (Nelson, 1984) have been used to replace maize in poultry diets. However, high level inclusion rates often yielded negative responses because of their high fibre content. Cassava root meal diets have been shown to produce encouraging results when fed to broilers (Tewe *et. al.,* 1980 and (Tion and Adeka, 2000), Plantain peel meal have also been used to substitute maize in broiler chicken diet up to 50% level without adverse effects (Ngum *et al* 2001). Substituting maize with Wild Bitter yam by more than 15% did not have any negative effect on broiler chicken production (Anyanwu and Ngwakwe, 2000). Both cassava and Wild Bitter Yam have been reported to contain toxic substances such as cyanide and alkaloid in which their presence in large quantity is a problem with plantain peel meals in particular.

One of the alternative crops that have potential to replace maize as a feed is sweet potato. The growing requirements for sweet potato can easily be met in a tropical country like Nigeria. The yield per hectare of about 85t/ha (FAO, 1990) is commendable, its potential as an efficient and economic source of food energy is high (Hahn, 1984). It is one of the highest calorie-yielding crops in the world, which makes it highly valuable in the tropics and developing world where most of the population depends on carbohydrate foods as dietary staples. Its cost of production has been found to be much lower than that of the cereals. This study is a follow up to an earlier study with broiler starters that was conducted to evaluate the potential of sweet potato as a source of energy in poultry diets (Afolayan, *et al.* 2012). The objective of this study was to determine whether sweet potato meal as a source of energy can be a good substitute for maize in broiler diets.

Materials and methods

Location

The study was conducted at the Poultry Unit of Samaru College of Agriculture's Livestock Farm, Ahmadu Bello University, Zaria in the Northern Guinea Savanna on latitude 11° 12' N of the equator and longitude 7° 33' with altitude 610mm and 1200mm, temperature ranges between 14.5°C during the early dry season (November – January) and 39.3°C during the late dry season, February – April (IAR, 2005).

Test Ingredients and diets

Yellow-skinned fresh sweet potato tubers were chopped into pieces of not more than 3cm thickness and 4cm length. The slices were sun-dried on concrete floors until the moisture content was reduced to about 10% in an atmosphere of 14.5% humidity at 27°C for 14 days. They were then milled to sizes suitable for easy consumption of broiler chickens to get the sweet potato meal (SPM). The SPM was then incorporated at levels of 0, 10, 20, 30, 40 and 50 percent into six iso-nitrogenous diets in both starter and finishing phases. The ingredients' compositions as well as the calculated proximate chemical composition of the diets are presented in Table 1 and 2 for starter and finishing experiments respectively.

Experimental Animals and Management

Starter phase (0–4wks): Two hundred and seventy (270) three day-old Ross broiler chicks obtained from local hatchery in Kano were used for the study. They were divided into equal groups of 15 birds, adjusting the groups' weight equally to approximately 74.67g/bird and distributed over 18 pens in a conventional deep litter house with the open sides covered with empty feed bags. Each pen had a dimension of 3.05 by 1.22m^2. Heat was provided by suspending 200Watt-electric bulb at a height of about 30.5cm into each pen. The six broiler starter formulated diets were assigned to the 18 groups of birds, each to three replicates in a completely randomized design. The control diet was formulated to meet the recommended levels of energy (3000kcals ME/kg) and protein (23%) established for broiler chicks in Nigeria (Dafwang, 2006). Feeds and water were supplied *ad-libitum* throughout the period of the experiment. Routine vaccinations were carried out as at when due. The chicks were brooded for 2 weeks. The feeding trial lasted 4 weeks.

Data Collection

The birds were weighed weekly during the study. Weighed left-over feed was subtracted from the total feed supply for the week to obtain feed consumption per week for each replicate. From the records taken, feed intake, weight gain, feed conversion ratio and feed cost per gain were calculated.

Finisher phase (5-9wks): Two hundred and fifty-two 4-week old Ross broiler chickens acquired from the starter phase study were used. The birds were fed a common starter diet for a period of one week after which they were weighed and divided into equal groups of 14 birds, adjusting the groups to approximately equal weight of 857.14g/bird. The groups were randomly distributed into 18 pens in the same deep litter house used for the chicks' study, however, with the side coverlets removed and the six iso-nitrogenous formulated finisher diets were assigned, each to three replicates in a completely randomized design. Feed and water were given *ad-libitum* throughout the period of the study. The feeding trial lasted 4 weeks. Data collection was carried out in the same way it was done in the starter phase study.

Carcass Evaluation

At the end of the study, two males and two females birds were picked randomly from each replicate. They were weighed individually before being slaughtered by cervical dislocation. The heart, liver, pancreas, gizzard and intestines were removed and weighed for determination of relative organ weights and dressing percentages.

Statistical Analysis

The data collected were summarized for each phase and subjected to Analysis of Variance (ANOVA). Where statistical significances were observed, the levels of significance were determined and the means were compared using the Duncan Multiple Range Test (DMRT) according to SAS (1995).

Results

Starter phase: The result of the broiler

Table 1: Composition of Experimental Broiler Diets (0 – 4 wks)

Ingredients (%)	Treatments (% SPM)					
	0	**10**	**20**	**30**	**40**	**50**
Maize	61.25	50.25	39.35	28.45	17.45	6.55
Sweet potato meal	0.00	10.00	20.00	30.00	40.00	50.00
Groundnut cake meal	26.50	27.50	28.40	29.30	30.30	31.20
Blood meal	6.00	6.00	6.00	6.00	6.00	6.00
Wheat offal	1.80	1.80	.80	1.80	1.80	1.80
Bone meal	3.40	3.40	3.40	3.40	3.40	3.40
Common salt	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
Lysine	0.25	0.25	0.25	0.25	0.25	0.25
Vit-min premix*	0.30	0.30	.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Analysis						
ME (Kcal/kg)	3032	2985	2940	2895	2849	2803
Crude protein (%)	23.05	23.08	23.06	23.05	23.08	23.06
Crude Fibre (%)	2.93	3.59	4.26	4.92	5.58	6.24
Calcium (%)	1.33	1.36	1.38	1.40	.43	1.45
Available phosphorus (%)	0.85	0.85	0.85	0.85	0.85	0.85
Lysine (%)	1.25	1.26	1.27	1.28	1.29	.30
Methionine (%)	0.55	0.54	0.54	0.53	0.52	0.52
Cystine (%)	0.37	0.37	0.36	0.36	0.36	0.36
Feed cost(N/kg) **	44.61	40.16	35.44	31.27	26.81	22.36

*Broiler chicks' vitamin premix supplied the followings per kg diet: Vit. A 10,000 IU, Vit.D_3 2,000 IU, Vit E 51 IU, Vit.K 2.34 mg, Riboflavin 5.5 mg, Vit.B12 10mg, Calcium pantothenate 10mg, Niacin 25mg, Choline Chloride 250mg, Folic acid 1mg, Manganese 56mg, Zinc 50mg, Copper 10mg, Iron 25mg, Cobalt 1.25mg, Amprolium 125mg and Tetracycline 100mg.

** At the time of experiment, the cost of maize was N40.00/kg while that of dried sweet potato chips was N20.00/kg

Table 2: Composition of Experimental Broiler Finisher Diets (5 – 9 Wks)

	Levels of dietary SPM (%)					
Ingredients (%)	0	10	20	30	40	50
Maize	60.55	49.60	38.65	27.75	16.80	5.85
Sweet potato meal	0.00	10.00	20.00	30.00	40.00	50.00
Groundnut cake	20.00	20.95	21.90	22.80	23.75	24.70
Blood meal	5.00	5.00	5.00	5.00	5.00	5.00
Wheat offal	10.00	10.00	10.00	10.00	10.00	10.00
Bone meal	3.40	3.40	3.40	3.40	3.40	3.40
Common salt	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
Lysine	0.25	0.25	0.25	0.25	0.25	0.25
Vit-min premix*	0.30	0.30	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Analysis						
ME (Kcal/kg)	3010	2964	2919	2873	2828	2782
Crude protein (%)	20.00	20.01	20.01	20.00	20.01	20.01
Crude Fibre (%)	3.47	4.13	4.79	5.46	6.12	6.78
Calcium (%)	1.32	1.34	1.36	1.39	1.41	1.43
Available phosphorous (%)	0.82	0.82	0.81	0.81	0.81	0.81
Lysine (%)	1.09	1.10	1.11	1.12	1.13	1.14
Methionine (%)	0.51	0.51	0.50	0.50	0.49	0.48
Cystine (%)	0.37	0.37	0.36	0.36	0.36	0.36
Feed cost(N/kg)**	42.91	38.46	34.01	29.56	25.11	20.66

*Broiler chickens' vitamin premix supplied the following per kg. diet: Vit A 10,000 IU, Vit.D_3 2,000 IU, Vit. E 51 IU, Vit. K 2.34mg, Riboflavin 5.5mg, Calcium pantothenate 10mg, Niacin 25mg, Cholic chloride 250mg, Folic acid 1mg, Manganese 56mg, Zinc 50mg, Copper 10mg, Iron 20mg, Cobalt 1.25mg, Amprolium 125mg and Tetracycline 100mg
** At the time of experiment, the cost of maize was N40.00/kg while that of dried sweet potato chips was N20.00/kg

starter study is summarized in Tables 3. The result showed that feed intake and mortality of the birds were not affected by dietary levels of sweet potato meal inclusion. However, the final weight, weight gain and feed efficiency became significantly negatively affected (P<0.05) when sweet potato meal was included beyond 30% level, the diets containing 40 and 50% SPM did not differ significantly (P>0.05) in these parameters. A significant (P<0.05) downward trend in the feed cost was observed with increase in dietary SPM levels. The feed cost/kg weight gain varied widely with the 50% SPM diet having the least value and control having the highest and significantly (P<0.05) different value compared with all other diets.

Finisher phase: The results of broiler finisher study are summarized in Tables 4 and 5. Observation from Table 4 showed that there were no significant (P>0.5) differences in the feed intake and mortality when chickens were fed on different dietary levels of SPM. However, differences occurred in the weight gain, feed:gain ratio, final weight and feed cost. While similar weight gain and feed:gain ratio were produced by diets containing 0, 10, 20 and 30 percent SPM, the diet containing 40 and 50 percent SPM produced a significantly (P<0.05) lower weight gain than the rest of the diets. On the other hand, the diets with 40 and 50 percent SPM had significantly (P<0.05) higher feed:gain ratio than the rest of the diets.

Table 3: Effect of Feeding Graded Levels of SPM Diets to Broiler Chicks (0 – 4 weeks)

	Levels of dietary SPM (%)						
Parameter	0	10	20	30	40	50	SEM
Initial weight (g/bird)	74.67	74.67	74.67	74.67	74.67	74.67	0.05
Final weight (g/bird)	585.88^{a}	586.98^{a}	589.29^{a}	558.57^{ab}	531.90^{b}	470.79^{b}	51.7
Weight gain (g/bird)	511.21^{a}	512.31^{a}	514.62^{a}	483.90^{ab}	457.23^{b}	396.12^{b}	31.7
Feed intake (g/bird)	1005.06	1014.79	1086.7	1087.4	1143.09	1026.04	41.1
Feed: Gain	1.97^{a}	1.98^{a}	2.11^{a}	2.25^{ab}	2.50^{b}	2.59^{b}	0.17
Daily weight gain(g/bird/day)	18.26^{a}	18.30^{a}	18.38^{a}	17.28^{ab}	16.33^{b}	14.15^{b}	1.26
Feed-intake (g/bird/day)	35.9	36.24	38.81	38.84	40.82	36.64	5.36
Feed Cost/kg gain (N)	87.71^{c}	79.54^{bc}	74.83^{b}	70.26^{b}	67.03^{ab}	57.91^{a}	9.62
Total cost of production (N/bird)	157.06^{c}	152.97^{c}	150.73^{bc}	146.22^{b}	142.87^{b}	135.16^{a}	6.41
Mortality (%)	2.28	2.28	2.28	2.28	2.28	2.28	0.02

^{abc} Means within the same row with different superscripts are significantly different (P<0.05)

SEM: Standard error of the means.

Table 4. Response of Broiler Chickens to Isonitrogenous Diets Containing Graded Levels of Sweet Potato (5 – 9 weeks)

	Levels of dietary SPM (%)						
Parameter	0	10	20	30	40	50	SEM
Initial wt (g/bird)	857.14	857.14	857.14	857.14	857.14	857.14	0.09
Final wt (g/bird)	2037.07^{a}	1944.05^{a}	1870.88^{ab}	1928.57^{a}	1766.67^{b}	1764.28^{b}	91.86
Wt gain (g/bird)	1180.16^{a}	1086.91^{a}	1013.74^{ab}	1071.43^{ab}	909.53^{b}	907.14^{b}	76.23
Feed intake (g/bird)	3826.54	3647.62	3767.60	3784.53	3670.24	3852.84	98.67
Feed: Gain	3.24^{a}	3.36^{a}	3.72^{a}	3.53^{a}	4.04^{b}	4.25^{b}	0.30
Daily Wt gain(g/bird/day)	42.15^{a}	38.82^{a}	36.21^{ab}	38.27^{ab}	32.48^{b}	32.4^{b}	5.92
Daily Feed-intake (g/bird/day)	136.66	130.27	134.56	135.16	131.08	137.60	2.94
Feed Cost/kg gain (N)	139.13^{a}	129.07^{b}	126.4^{b}	104.41^{c}	101.33^{c}	87.75^{d}	13.28
Mortality (%)	0.00	0.00	0.00	0.00	2.38	0.00	1.30

^{abcd} Means within the same row with different superscripts are significantly different (P<0.05)

SEM: Standard error of the means.

Table 5: Effect of Feeding Graded levels of SPM Diets on Carcass Measurements and certain Organs of Finisher Broiler Chickens

Parameters	Levels of dietary SPM (%)						
	0	10	20	30	40	50	SEM
Live weight (kg)	2.02^{a}	1.94^{a}	1.87^{a}	1.93^{a}	1.77^{a}	1.76^{b}	0.07
Carcass weight (kg)	1.48^{ab}	1.43^{a}	1.37^{a}	1.41^{a}	1.29^{a}	1.27^{b}	0.06
Dressing %	73.2^{a}	73.5^{a}	73.0^{a}	73.0^{a}	72.7^{ab}	72.4^{b}	0.25
Head weight (g/100g)	0.050	0.060	0.070	0.050	0.060	0.060	0.01
Neck weight (g/100g)	0.120	0.100	0.270	0.090	0.290	0.080	0.12
Shank weight (g/100g)	0.200	0.100	0.180	0.150	0.090	0.090	0.07
Spleen weight (g/100g)	0.008	0.006	0.007	0.008	0.007	0.006	0.00
Abdominal fat weight (g/100g)	0.07	0.06	0.06	0.07	0.07	0.05	0.02
Liver weight (g/100g)	0.035	0.034	0.040	0.042	0.043	0.043	0.00
Heart weight (g/100g)	0.024	0.020	0.023	0.020	0.021	0.017	0.00
Lung weight (g/100g)	0.022	0.015	0.023	0.018	0.020	0.017	0.00
Gizzard weight (g/100g)	0.025	0.025	0.025	0.028	0.020	0.020	0.01
Length of large intestine (cm)	13.53^{b}	13.90^{b}	14.15^{b}	14.90^{ab}	14.98^{a}	15.37^{a}	0.50
Caecal Length (cm)	18.90	20.10	21.10	21.90	21.85	21.92	1.71
Length of small intestine (cm)	182.52^{b}	190.60^{b}	196.38^{ab}	198.60^{ab}	203.26^{a}	206.50^{a}	5.20

^{abc} Means within the same row with different superscripts are significantly different ($P \leq 0.05$),

SEM: Standard error of the means.

Carcass parameters: The result of the studies on the carcass parameters and body organs summarized in Table 5 showed that treatments had no significant effect on the relative weights of abdominal fat, gizzards, heads, hearts, livers, lungs, necks, shanks and spleens as these parameters did not show differences across the diets. In contrast, significant differences in lengths of both small and large intestines, with the control, 10 and 20%SPM diets producing significantly shorter ($P<0.05$) lengths of small and large intestines than the 40% and 50%SPM diets. Significant difference ($P>0.05$) did not occur in carcass weight and dressing percent until the inclusion of sweet potato meal content of feed was raised to 50%.

Discussion

Earlier workers (Domínguez, 1990, Shoremi and Job, 2000 and Maphosa *et. al.*, 2003) observed decrease in feed intake when SPM was substituted for maize in their studies and attributed the decrease to the dusty and gritty nature of SPM, however, the results of the present studies showed that feed intake was similar at all levels of dietary SPM inclusion and suggest that energy and protein deficiency may be more important factors contributing to the decreased feed intake observed at higher levels of dietary SPM by the earlier workers. The observation that high levels of dietary SPM inclusion results in decreased final body weight and weight gain is in agreement with the earlier reports of Turner *et. al.*, (1976), Maphosa *et. al.*, (2003) and Ayuk (2004). The final body weight, weight gain and feed conversion were similar for the diets containing 0 - 30% SPM. This suggests that for iso-nitrogenous diets, SPM can be included at levels up to 30% without any adverse effect on growth performance. The decrease in feed efficiency with increasing levels of dietary SPM observed in this study and in the results of Tewe, 1991; Bansa *et al.* 2000 and Maphosa *et al.* 2003 indicates that anti-nutritional factors other than TIA(8.9mg/100g), HCN(0.67ug/100g) and phytic acid (0.082g/100g) analyzed by Afolayan (2010) in SPM may be responsible for the poorer utilization of diets with increasing levels of SPM. This result points to the need for further research into the factors responsible for the poorer feed efficiency with increasing levels of dietary SPM. Maphosa *et. al.*, (2003) amongst others suggested that the dusty nature of SPM may have led to faster rate of passage through the gut and consequently results into poor utilization. Possibility of microbial growth on the sweet potato chips while being sun dried before milling was also suggested by Moy and Chi (1983) as a factor that could contribute to the poor efficiency of utilization of SPM diets. The observation that the feed cost per kg weight gain was least on the 50% SPM diet reflects the justification for this study. In the course of this trial, the cost of maize was N40/kg compared to N20/kg for sweet potato chips. This has no doubt made the inclusion of sweet potato meal economical even at 30% level of inclusion The mortality rate of 2.38% recorded in the course of feeding 40%SPM diet was accidental, as it was observed that all other diets; including diet with the highest 50%) level of SPM inclusion had no mortality rate. Afolayan (2010) had earlier estimated the levels of major anti-nutritional factors in sweet potato meal and established that its low contents had no negative effect on the performance of chickens fed sweet potato meal diets.

Conclusion

It can be concluded from this study that sweet potato meal should not be added beyond 30% level in a maize-based diet when the starter and finisher diets contain 23 and 20%CP respectively.

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