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Response of Broiler Chickens Fed on Maize-based Diets Substituted with Graded Levels of Sweet Potato Meal

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ABSTRACT

Sweet Potato Meal (SPM) was used to substitute maize on weight for weight basis as a dietary source of energy for starter and finisher chickens. The SPM was incorporated at 0, 10, 20, 30, 40, 50 and 60% levels in both studies without adjustments for energy and protein. Ross broiler chicks obtained from a local hatchery were used for the studies. Three replicates of 15 chicks each were randomly allocated to each of the 7 treatments in a Completely Randomized Design (CRD) for the starter phase while the number of birds was reduced to 14 per group for the finisher phase. Parameters measured or calculated include feed intake, body weight gain, feed efficiency, feed cost, feed cost/kg wt. gain, mortality and carcass characteristics. The starter phase study was on 1 to 5 week-old chicks while the finisher study was on 6 to 9 week-old chickens. The trend of results in the two phases were similar and showed that weight gain, feed intake and total cost of raising birds decreased significantly ($p<0.5$) while the feed cost/kg wt. gain and feed: gain ratio increased ($p<0.05$). The control, 10 and 20% SPM diets gave similar feed efficiency. The control gave the best performance, though its performance was not different ($p>0.05$) from those of the 10 and 20% SPM diets. Dietary SPM levels had no adverse effects on mortality and carcass characteristics. It is concluded that SPM should not be included beyond 20% level when substituted for maize on a weight for weight basis without adjusting the dietary protein and energy.

Key words: Sweet potato meal, broiler chicken, diets

INTRODUCTION

Nigerian poultry farmers continue to experience a rise in cost of production as a result of the increasing cost of feeds. Inadequate knowledge and non-availability of alternative and cheaper feed resources and competition between man and animals for most of the conventional feedstuffs have been identified as the root cause. Prices of conventional energy sources in Nigeria for feeding chickens keep on increasing. Of these energy sources, maize is the most widely used and its price in the market has been the most unpredictable. This is partly because it has so many alternative uses and its production has not been able to meet the demands by both man and animals. Within the past three years, its price has fluctuated between N20.00 and N80.00 kg^{-1} while those of unconventional feed sources like sweet potato remained virtually stable and cheap (Afolayan, 2010).

Maize is currently the most widely used grain crop in Nigeria, also being used to a level of between 40-60% as the conventional energy source for poultry. Its price keeps on rising to a level of causing instability in the poultry industry and the prospect of increasing its production to the magnitude that can satisfy its various uses is an illusion. There is therefore an urgent need to search for alternative energy sources if the collapse of poultry industry is to be saved. Now that all efforts to produce maize in quantities that could meet the country's needs have not been successful, there is urgent need to search for maize substitutes. Non-conventional feedstuffs, according to Dafwang (2006) offer the best alternative in Nigeria for the reduction of feed cost and cost of animal products. It is for this reason that sweet potato which at present has limited alternative uses, cheap and has a stable price, is being considered for evaluation in the feeding of broiler chickens.

Sweet potato is one of the tuber root crops whose cultivation is fast gaining ground in Nigeria. Presently it is being grown exclusively for human consumption, while its foliage has always been considered as forage (Dominguez, 1992). In research stations, the estimated yield of some improved varieties in Nigeria vary from 40-70 t/ha/crop of roots and average yield of 23.5 t ha^{-1} had been recorded in different zones of the country (Tewe *et al.*, 2003). Its main nutritional importance has been its starch content; however, nutrients such as vitamin A, ascorbic acid, thiamine, riboflavin and niacin are also adequate. Carbohydrates constitutes about 80-90% of dry weight of the tuber. Sweet potato has been evaluated as a source of energy in the diets of pigs (Lee *et al.*, 1977; Lee and Yang, 1979; Manfredini *et al.*, 1990; Rose and White, 1980; Wu, 1980), however, information on the use of SPM by broiler chicken is still limited. The objective of this study was to compare maize and sweet potato as sources of energy on a weight to weight basis in broiler chicken diets and determine the level to which sweet potato can be substituted for maize as a source of energy in broiler diets.

MATERIALS AND METHODS

Starter phase (1-5 week): Three hundred and fifteen day-old Ross broiler chicks obtained from a local hatchery were used for this study. The chicks were fed a common pre-starter commercial diet for a period of one week after which they were divided into equal groups of 15 birds, adjusting the groups to approximately equal weights. The birds had an initial average weight of 92.00 g per bird at one-week old. The groups were then randomly distributed into 21 pens and seven treatments were assigned, each to three replicates in a completely randomized design. The treatments consisted of diets containing 0, 10, 20, 30, 40, 50 and 60% levels of SPM. Feeds and water were given to birds *ad libitum*. The birds were weighed weekly and records of feed consumption, body weight, weight gain and mortality were kept for each treatment group. The feeding trial was conducted in the month of February and lasted 4 weeks. The data collected were summarized and then subjected to Analysis of Variance (ANOVA) and where statistical significance was observed, the means were compared using the DMRT according to SAS (1995). The ingredients compositions as well as the calculated proximate chemical composition of the diet supplied are shown in Table 1.

Finisher phase (6-9 week): For this study, two hundred and ninety-four 5-week old Ross broiler chickens acquired from the starter study were used. The birds were fed a common starter diet for a week after which they were divided into equal groups of 14 birds, adjusting the groups to approximately equal weights of 1200 g $bird^{-1}$ at six weeks old. The groups were randomly distributed into 21 pens and seven treatments were assigned, each to three replicates in a completely randomized design. The treatments consisted of diets containing 0, 10, 20, 30, 40, 50 and 60% levels of SPM substituted for maize on a weight for weight basis. Feed and water were given to birds *ad libitum*. The birds were weighed weekly and records of feed consumption, body weight, weight gain and mortality were kept for each treatment group. The feeding trial was conducted in March and lasted 3 weeks. The ingredients compositions as well as the calculated proximate

Table 1: Composition of experimental broiler starter diets

	Levels of dietary SPM (%)						
Ingredients (%)	0	10	20	30	40	50	60
Maize	60.00	50.00	40.00	30.00	20.00	10.00	0.00
Sweet potato meal	0.00	10.00	20.00	30.00	40.00	50.00	60.00
Groundnut cake	29.70	29.70	29.70	29.70	29.70	29.70	29.70
Blood meal	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Wheat offals	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Bone meal	3.25	3.25	3.25	3.25	3.25	3.25	3.25
Common salt	0.25	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	0.25
Lysine	0.25	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	0.30
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis							
ME (kcal kg^{-1})	3016.00	2993.00	2970.00	2946.00	2923.00	2990.00	2877.00
Crude protein (%)	23.68	23.31	22.95	22.58	22.22	21.86	21.49
Crude fibre (%)	2.92	3.58	4.23	4.88	5.53	6.18	6.84
Calcium (%)	1.28	1.30	1.32	1.35	1.37	1.39	1.41
Available phosphorous (%)	0.85	0.85	0.84	0.84	0.83	0.83	0.83
Lysine (%)	1.23	1.23	1.23	1.22	1.22	1.22	1.22
Methionine (%)	0.55	0.54	0.54	0.53	0.52	0.51	0.50
Cystine (%)	0.37	0.37	0.36	0.36	0.36	0.36	0.36
Feed cost (N kg^{-1})**	28.60	28.60	28.60	28.60	28.60	28.60	28.60

*Broiler chicks' vitamin premix supplied the following per kg. diet: Vit A 10,000 IU, vit. D3: 2,000 IU, vit. E: 51 IU, vit. K: 2.34 mg, Riboflavin: 5.5 mg, Calcium pantothenate: 10 mg, Niacin: 25 mg, Choline chloride: 250 mg, Folic acid: 1 mg, Manganese: 56 mg, Zinc: 50 mg, Copper: 10 mg, Iron: 20 mg, Cobalt: 1.25 mg, Amprolium: 125 mg and Tetracycline: 100 mg. **At the time of experiment, the costs of maize and dried sweet potato chips were the same (N20.00 kg^{-1})

chemical composition of the diet supplied are shown in Table 2. At the end of the study, two male and two female birds were picked randomly from each pen. They were weighed individually before being killed by cervical dislocation. The heart, liver, pancreas, gizzard and intestines were removed and weighed for determination of relative organ weights and dressing percentages. The data collected were summarized and then subjected to Analysis of Variance (ANOVA) and where statistical significance was observed, the means were compared using the DMRT according to SAS (1995).

RESULTS

The result of the broiler starter study is summarized in Table 3. The inclusion of sweet potato meal had a negative effect ($p<0.05$) on the performance of chicks. The final weight and weight gain decreased significantly ($p<0.05$) in a linear manner as the level of SPM increased in the diets. Similarly, the feed intake and total cost of production decreased significantly ($p<0.05$) as the level of SPM increased in the diet. The feed cost/kg wt. gain and feed: gain ratio increased significantly ($p<0.05$) as the dietary SPM level increased. Most of the parameters measured were statistically similar for the control and 10% SPM diets, however, the efficiency of feed conversion were similar for the control, 10 and 20% SPM diets. Sweet potato level had no significant effect on mortality.

Table 2: Composition of experimental broiler finisher diets

	Treatment (% SPM)						
Ingredients (%)	0	10	20	30	40	50	60
Maize	60.00	50.00	40.00	30.00	20.00	10.00	0.00
Sweet potato meal	0.00	10.00	20.00	30.00	40.00	50.00	60.00
Groundnut cake meal	18.00	18.00	18.00	18.00	18.00	18.00	18.00
Blood meal	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Wheat offal	12.00	12.00	12.00	12.00	12.00	12.00	12.00
Bone meal	3.25	3.25	3.25	3.25	3.25	3.25	3.25
Common salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Lysine	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Vit-min premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis							
ME (Kcal kg^{-1})	2992.00	2969.00	2946.00	2922.00	2899.00	2876.00	2853.00
Crude protein (%)	20.72	20.36	19.99	19.63	19.26	18.90	18.54
Crude Fibre (%)	3.59	4.25	4.90	5.55	6.20	6.85	7.51
Calcium (%)	1.27	1.29	1.31	1.33	1.35	1.37	1.39
Avail. phosphorus (%)	0.80	0.79	0.79	0.78	0.78	0.78	0.78
Lysine (%)	1.01	1.01	1.01	1.00	1.00	1.00	1.00
Methionine (%)	0.42	0.42	0.41	0.40	0.39	0.38	0.37
Cystine (%)	0.30	0.30	0.30	0.30	0.30	0.29	0.29
Feed cost (N kg^{-1})**	25.27	25.27	25.27	25.27	25.27	25.27	25.27

*Broiler finishers' vitamin premix supplied the following per kg. diet: Vit A 10,000 IU, Vit. D3: 2,000 IU, vit. E: 51 IU, vit. K: 2.34 mg, Riboflavin: 5.5 mg, Calcium pantothenate: 10 mg, Niacin: 25 mg, Choline chloride: 250 mg, Folic acid: 1 mg, Manganese: 56 mg, Zinc: 50 mg, Copper: 10 mg, Iron: 20 mg, Cobalt: 1.25 mg, Amprolium: 125 mg and Tetracycline: 100 mg, **At the time of experiment, the costs of maize and dried sweet potato chips were the same (N20.00 kg^{-1})

Table 3: Response of broiler chicks to graded levels of SPM in starter diets (1-5 weeks)

	Levels of dietary SPM (%)								
Parameters	0	10	20	30	40	50	60	SEM	Sig.
Initial wt. (g $bird^{-1}$)	92.00	91.78	91.56	91.56	92.00	91.56	92.00	0.06	NS
Final wt. (g $bird^{-1}$)	1067.96^{a}	1009.16^{b}	978.67^{c}	909.56^{d}	850.89^{de}	791.60^{e}	670.45^{f}	3.80	*
Weight gain (g $bird^{-1}$)	975.96^{a}	917.38^{ab}	867.11^{bc}	818.00^{cd}	758.89^{de}	700.04^{e}	578.45^{f}	25.18	*
Feed intake (g $bird^{-1}$)	2050.68^{a}	1921.33^{ab}	1853.88^{b}	1859.11^{b}	1802.23^{bc}	1808.46^{bc}	633.78^{c}	57.36	*
Feed: gain	2.10^{a}	2.09^{a}	2.14^{ab}	2.27^{bc}	2.37^{c}	2.58^{d}	2.82^{e}	0.05	*
Weight gain (g/bird/day)	34.86^{a}	32.76^{ab}	30.97^{bc}	29.21^{cd}	27.10^{de}	25.00^{e}	20.66^{f}	1.69	*
Feed-intake (g/bird/day)	73.24^{a}	68.62^{ab}	66.21^{b}	66.40^{b}	64.37^{bc}	64.59^{bc}	58.35^{c}	2.05	*
Feed cost/kg gain (N)	60.09^{a}	59.90^{a}	61.15^{a}	65.00^{b}	67.91^{b}	73.88^{c}	80.78^{d}	7.60	*
Total cost of prodn. (N $bird^{-1}$)	217.60^{c}	214.10^{c}	212.17^{bc}	212.32^{bc}	210.69^{b}	210.87^{b}	185.88^{a}	9.58	*
Mortality (%)	2.20	2.20	0.00	2.20	0.00	2.20	0.00	2.20	NS

^{abcdef}Means within the same row with different superscripts are significantly different ($p<0.05$), SEM: Standard error of the means, NS: Not significant, *Significant, prodn: Production

The results of broiler finisher study are summarized in Table 4 and 5. It was observed that performance of finisher chickens in terms of weight gain, final weight and feed: gain ratio became negatively ($p<0.05$) affected when SPM was included beyond 20% level. Responses of birds to SPM

Table 4: Response of broiler chickens to graded levels of SPM in finisher diets (6-9 weeks)

	Levels of SPM (%)								
Parameters	0	10	20	30	40	50	60	SEM	Sig.
Initial wt. (g bird^{-1})	1200.48	1190.95	1200.48	1198.10	1200.48	1200.48	1200.48	0.05	NS
Final wt. (g bird^{-1})	2310.01^{a}	2308.81^{a}	2160.01^{ab}	2016.43^{b}	1984.64^{bc}	1852.86^{c}	1795.71^{c}	75.10	*
Weight gain (g bird^{-1})	1109.53^{a}	1117.86^{a}	959.53^{ab}	818.33^{b}	784.16^{bc}	652.38^{cd}	595.23^{d}	79.30	*
Feed intake (g bird^{-1})	3135.72^{a}	3110.31^{a}	3011.91^{ab}	2888.10^{ab}	2915.64^{ab}	2809.76^{b}	2873.80^{b}	123.90	*
Feed: gain	2.83^{a}	2.79^{a}	3.14^{ab}	3.53^{bc}	3.72^{c}	4.31^{d}	4.83^{e}	0.21	*
Daily wt. gain (g/bird/day)	52.83^{a}	53.23^{a}	45.69^{ab}	38.97^{b}	37.34^{bc}	31.07^{c}	28.34^{c}	3.80	*
Daily feed-intake (g/bird/day)	149.32^{a}	148.11^{a}	143.42^{ab}	137.53^{ab}	138.84^{ab}	133.80^{b}	136.85^{b}	5.92	*
Feed cost/kg gain (N)	71.41^{a}	70.31^{a}	79.32^{b}	89.18^{b}	93.96^{bc}	108.83^{cd}	122.00^{d}	6.62	*
Mortality (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NS

^{abcde}Means within the same row with different superscripts are significantly different (P<0.05), SEM: Standard error of the means, NS: Not significant, *Significant

Table 5: Effect of feeding graded levels of SPM diets on carcass measurements and certain organs of finisher broiler chickens

	Levels of SPM (%)								
Parameters	0	10	20	30	40	50	60	SEM	Sig.
LWt (kg)	2.11^{a}	2.22^{a}	2.10^{a}	2.12^{a}	2.08^{a}	1.92^{b}	1.75^{c}	0.07	*
CWt (kg)	1.53^{ab}	1.63^{a}	1.52^{a}	1.53^{a}	1.52^{a}	1.37^{b}	1.21^{c}	0.06	*
Dressing (%)	72.5	73.40	72.4	72.2	73.1	71.4	69.1	0.22	NS
Head wt. (g/100 g)	0.050	0.060	0.070	0.050	0.060	0.060	0.050	0.01	NS
Neck wt. (g/100 g)	0.100	0.080	0.270	0.090	0.290	0.080	0.070	0.12	NS
Shanks wt. (g/100 g)	0.100	0.100	0.280	0.250	0.080	0.110	0.090	0.09	NS
Spleens wt. (g/100 g)	0.008	0.006	0.007	0.008	0.007	0.006	0.006	0.00	NS
Abdominal wt. (g/100 g)	0.05	0.08	0.06	0.08	0.07	0.05	0.05	0.02	NS
Liver wt. (g/100 g)	0.038	0.034	0.043	0.040	0.038	0.038	0.033	0.00	NS
Heart wt. (g/100 g)	0.023	0.015	0.023	0.020	0.020	0.017	0.017	0.00	NS
Lung wt. (g/100 g)	0.022	0.015	0.023	0.018	0.020	0.017	0.016	0.00	NS
Gizzards wt. (g/100 g)	0.025	0.025	0.025	0.028	0.020	0.020	0.013	0.01	NS
Large intestine length (cm)	13.38^{b}	14.30^{b}	14.15^{b}	15.43^{a}	14.98^{ab}	15.37^{a}	15.38^{a}	0.50	*
Caecal length (cm)	19.900	20.90	21.55	20.90	21.85	21.92	20.78	2.03	NS
Small intestine length (cm)	181.32^{b}	190.25^{b}	196.38^{ab}	198.80^{ab}	206.25^{a}	211.45^{a}	198.68^{ab}	7.60	*

^{abc}Means within the same row with different superscripts are significantly different (p<0.05), SEM: Standard error of the means, NS: Non-significant, *Significant

levels at both 0, 10 and 20% levels of substitution in these three parameters were similar but significantly (p<0.05) different from the responses to the other levels. However, feed intake did not decrease significantly (p<0.5) until dietary SPM exceeded 40%, while mortality was not affected by levels of dietary SPM inclusion. Beyond 20% level of SPM inclusion, the final weight and weight gain decreased significantly (p<0.05) in a linear manner as the level of SPM increased in the diets while the feed: gain values increased (p<0.05). The feed cost/kg weight gain for the control and 10% SPM diets were similar and significantly lower than the feed cost/kg weight gain obtained for all other diets. Table 5 showed that treatments had no significant effect on the relative weights of gizzards, lungs, hearts, livers, spleens, shanks, necks, heads and abdominal fat, as these parameters did not show differences across the diets. However, there were 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 rest of the diets.

DISCUSSION

Weight gain and feed consumption: The decline in body weight gain and feed consumption with increasing levels of SPM is similar to the results of Maphosa *et al.* (2003).

The decline became significantly different from that of the control diet when levels of SPM exceeded 10% in starter diets and 20% in finisher diets. This is in contrast to Lee and Yang (1979) report who did not observe any adverse effect on performance when corn was substituted with about 24% SPM in broiler diet. Agwunobi (1999) also reported no adverse effect when SPM was fed at 27 and 30% levels respectively in broiler starter diets. The significant decline in body weight, weight gain and feed consumption in the two studies may be due to the progressive decline in dietary energy and protein levels as well as increase in dietary fibre with increasing levels of dietary SPM. The higher levels of SPM used by Lee and Yang (1979) and Agwunobi (1999) was probably a result of the use of isocaloric and isonitrogenous diets in their experiments. A decline in weight gain was also observed in growing pigs (35-60 kg) by Gonzalex *et al.* (2002) when sweet potato root meal was fed beyond 50% replacement level of maize, indicating that SPM can not be fed as a sole source of energy in growing pig ration.

Feed conversion and feed cost per kg weight gain: Feed conversion and feed cost/kg weight gain in contrast to weight gain and feed consumption, increased with increased levels of SPM. Given the fact that animals in general are known to eat in order to satisfy their energy requirements first and foremost (NRC, 1994), birds increase their feed intake as the energy level of diets decreased. The birds in the present studies could not increase feed intake to match their energy needs. Banser *et al.* (2000) suggested that the low feed intake may be due to palatability problems associated with the nature of SPM which tends to be dusty and less digestible. The lower feed consumption and poorer efficiency of feed utilization led to the increase in feed conversion ratio and subsequently higher feed cost per kg weight gain. The results observed for these two parameters are in agreement with the reports of Maphosa *et al.* (2003) and Ayuk (2004). The result for feed conversion ratio and feed cost/kg weight gain suggest that SPM level should not exceed 20% in broiler chicken diets if substituted for maize on a weight for weight basis. Trend similar to those observed in feed conversion ratio for the current experiments was also observed when sweet potato root meal was fed at graded levels to growing pigs (Gonzalex *et al.*, 2002), these researchers attributed the trend to poor digestibility engendered by inherent anti-nutritional factor in sweet potato.

Mortality: The mortality rate of about 2% in the starter phase is within acceptable limits for broiler chicken and the zero mortality at the finisher phase showed that it was not related to dietary SPM levels. This is not surprising since the level of anti nutritional factors in SPM which could have contributed to mortality had been established to be low. The result here is similar to that of Tewe (1994) and Ravindran and Sivakanesan (1996). In contrast, Maphosa *et al.* (2003) reported a linear increase in mortality with increased SPM inclusion in broiler chicken diets and attributed the occurrence to gastro intestinal disorder caused by high soluble sugar content of sweet potato. The difference in this result and that of Maphosa *et al.* (2003) may be due to the difference in the type of sweet potato cultivar used. However, no death has been reported as a result of feeding sweet potato root meal to pigs.

Carcass characteristics: It is generally recognized that feed ingredients with high fibre content tend to result in bigger gizzard and longer gut. The observation that gizzard weight did not increase in this case is a contradiction. If the longer gut length observed in this study was simply due to the fibrous nature of SPM, the gizzard weight would have increased with increasing levels of dietary SPM.

It is concluded from these results that on weight for weight basis, the substitution level of SPM for maize should not exceed 10% at starter phase and 20% at finishing phase.

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