Nig. J. Anim. Prod. 2018, 45(2): 114 - 123

Dietary evaluation of fermented cocoyam tuber meal (*Xanthosoma sagitifolium*) as energy source in place of maize in broiler chicken production

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Abstract

Considering the inherent attributes of cocoyam tuber meal (Xanthosoma sagitifolium) and its appropriate utilization in chicken diets may enhance performance of broiler chicken. This study was therefore carried out to determine the dietary evaluation of fermented cocoyam tuber meal as energy source in the diets of finisher broiler production. The objectives of the study were to determine the proximate composition of raw and fermented coco yam tuber meal and their anti-nutrient content (Tannin), cyanide, saponin, phytate and oxalate); to determine the effects of replacement value of maize with different levels of fermented coco yam tuber meal on the growth performance of broilers; to determine the economics of production of broilers using such diets. The fermented cocoyam was used to replace maize at various levels to determine the best level that would give optimal performance in broilers diets. One hundred and fifty (150) agrited finisher Anak broilers at 4 week were used for this experiment. The proximate composition of fermented cocoyam meal showed that it contained 19.15% moisture, 1.30% ash, 3.56% crude protein, 5.30% crude fiber, 1.90% ether extract and 25.48% NFE. In the finisher trial, the replacements were 25%, 50%, 75% and 100% of FCYM for maize in the control diet. Each finisher diet was fed to a group of 30 finisher broilers at 4 weeks using Completely Ramdomized Design (CRD). The parameters measured include: initial body weight, final body weight, body weight gain, feed intake, feed conversion ratio, cost of production and carcass characteristics. In the finisher feeding trial, the broiler group on 25% FCYM recorded the highest body weight gain which was significantly different (P<0.05) from those on the control diet and the rest of the treatment groupsThe internal organs expressed as percent of the live weight were not affected by the treatments. The cost of production (N135.28) was lowest for diets 5 (100% FCYM) while the highest was the control treatment. The result of the trial have shown that 4 day fermentation of cocoyam tubers for processing broiler diets was quite an effective method of processing cocoyam tubers for use in broiler diets because fermentation reduced the anti-nutrient contents in cocoyam tubers. It was concluded that fermented cocoyam tuber meal could be used in the diet of finisher broilers up to 100% without affecting body weight gain, feed intake and feed conversion ratio as indicated in this study.

Keywords: Dietary evaluation, Fermented cocoyam, Energy source, Broiler chicken

Introduction

Milk, meat, and eggs, "the animal source foods," though expensive sources of protein are one of the best sources of high quality protein and micro nutrient that are essential for normal development and good health. Every adult or grown up person should consume at least 35g of animal protein daily (FAO, 1982) (Aduku and Olukosi, 1990), (Oyenuga, 1997), but the average in West Africa is 7g (Oluyemi, 1978). The high cost of livestock feed has caused the rise in the prices of animal products such as meat, eggs and milk. This has affected the animal protein intake by Nigerians. (Adejinmi *et al.,* 2000) reported that rising cost of feed resources in livestock production has been established as a serious impediment to meeting the demand of animal protein particularly in developing countries. The high cost of feed ingredients especial grains is due to competition for grains especially maize between man, livestock and industries.

This stimulates the use of alternative sources of energy that abound in many areas of humid tropics. Although roots and tubers are cheap sources of energy, the extent of their practical use in non ruminant feeding has been limited. For example in Nigeria, 5 percent of the total of the cassava production is used as feed, while a lower percent of coco yam products is used as livestock feed (Tewe *et al.,* 1997). The term cocoyam is used to refer collectively to members of the genus colocasia and the genus Xanthosoma which are used for food and feed, when referred to separately, colocasia species are called taro while Xanthosoma species are called tannia. Cocoyam is recognized as cheaper carbohydrate source than grains or other tuber crops (Obioha, 1972). It has high caloric yield per hectare, low production cost (Hahn, 1984) and relatively low susceptibility to insect and pest attack. Similarly, it is reported that cocoyam has readily digestible starch content because of its small particle size (Lyonga and Nzetcheng, 1986; Ezedinma, 1987). It is almost competition-free with man in most places as it is eaten only as a last resort when a family can no longer afford garri or yam. It is therefore more likely to be available for use at lower cost.

However, its use in the feeding of monogastric animal could be encumbered by the presence of some anti-nutritional factors (Oxalate, Tannins, and trypsin inhibitors) which adversely affect protein and energy utilization in broiler chickens (Onu *et al.*, 2004). These anti-nutritive factors can be reduced through cooking and drying of the cocoyam corms before using them.

Considering the various attributes of cocoyam (*Xanthosoma sagitifolium*), it would appear, that appropriate utilization of this feed stuff can be used to replace maize to produce low cost diets that can be efficient in promoting the performance of finisher broiler chicken and reduce demand pressure on maize as well as cost of production.

Materials and methods

Experimental site

The experiment was carried out at the poultry unit of Teaching and Research Farm of Michael Okpara University of Agriculture, Umudike, Umuahia, Abia State, Nigeria. The area is located on latitude 5^0 21^1 North, longitude 7^0 32^1 East, in the rain forest zone in umuahia, Abia State. 27^0C– 36^0C and minimum of 20^0-26^0C with relative humidity between 57^0 and 91% Eburuaja (2010) and annual rainfall of 200mm per annum and an altitude of 122m above sea level. It is therefore, a humid tropical environment with temperature and relative humidity that are significant for agricultural production (Eburuaja, 2010).

Procurement and processing of feed ingredients

Tannia cocoyam corms (*Xanthosoma sagitifolium*) were obtained from Ehime Mbano Local Government Area in Imo State. The corms were harvested, cleaned and chopped into bits of about 0.20cm. Chopped cocoyam was fermented in water in large vats for 4 days to reduce the anti nutrients content and lateron separated from the water and dried with electric oven. The dried cocoyam was milled and then stored for use.

Other ingredients like maize, palm kernel cake, brewers dried grains, blood meal, fish meal, bone meal, vitamin premix, lysine, methionine, salt etc were bought from jocan livestock services in umuahia, Abia State.

Chemical analysis of feed ingredients

All the processed feed ingredients, fermented cocoyam tuber meal, palm kernel cake, brewers' dried grains, blood meal, fish meal were subjected to proximate analysis according to AOAC (1995) to determine their nutrients composition and gross energy. All analysis was based on 100% dry matter. This was done so as to use the values that were obtained to determine the nutrient composition of the experimental diets that were formulated from them. The components that were determined include, Dry Matter (DM), Crude Protein (CP), Ether Extract (EE) and Nitrogen Free Extract (NFE).

Anti-nutrients determination

The test materials, fresh and fermented cocoyam tubers (*Xanthosomasagitifolium*) were analyzed for anti nutrients content, such as oxalate, phytic acid, saponins, tannins and cyanide. Phytate was determined according to Joslyn (1970); Saponins was determined according to Brunner (1984). Cyanide content of the cocoyam meal was determined using picarate paper kit developed by (Bradbury et al; 1999) and oxalate was determined according to Harborne (1973).

Experimental finisher broilers diets

Five experimental diets were formulated for the finisher phase of the feeding trial. The control diet (diet 1) contained 60% maize as the major source of energy, while diets 2, 3, 4, and 5, contained as the major source of energy and fiber, fermented cocoyam tuber meal (FCYM) at 25%, 50%, 75% and 100%, respectively to replace maize. Other ingredients remained the same in the diets (Table 1)

Experimental design

The design of the study was Completely Randomized Design (CRD)

The statistical model is;

$$Y_{ij} = \mu + T_i + e_{ji}$$

Where; Y_{ij}= individual observation,μ= population mean,T_i= Treatment effect,e_{ij}= Error effect

Table 1: Percentage ingredients and nutrient composition of finisher broilers experimental diets

Ingredients (%)	Diet 1 (Control)	Diet 2 25% FCYM)	Diet 3 (50% FCYM)	Diet 4 75% FCYM)	Diet 5 (100% FCYM)
Maize	60.00	45.00	30.000	15.000	0.00
FCYM*	0.00	15.00	30.00	45.00	60.00
Palm kernel cake	4.20	4.20	4.20	4.20	4.20
Brewers' dried Grains	8.20	8.20	8.20	8.20	8.20
Soyabean meal	17.00	17.00	17.00	17.00	17.00
Fish meal	3.00	3.00	3.00	3.00	3.00
Blood meal	2.40	2.40	2.40	2.40	2.40
Vit./mineral premix **	0.25	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10	0.10
Common salt	0.25	0.25	0.25	0.25	0.25
Palm oil	1.50	1.50	1.50	1.50	1.50
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Nutrient Composition of the Experimental Finisher Diets					
Crude Protein	20.47	20.27	20.07	21.17	20.27
ME,Kcal/kg	3002.72	2951.72	2819.72	2849.72	2800.00

*** Fermented cocoyammeal ** To provide per kg diet; vit A, 200, 000iu, vit. D 3 4,000; Vit E, 80g;Choline, 48.00g; BHT, 32.00g;Manganese, 16.00g; iron, 8.00mg; zinc, 72g; copper, 0.32g; Iodine, 0.25g; cobalt, 36.00mg; selenium, 16.00g.**

Management of the experimental finisher broiler chicks

A four week feeding trial was conducted using unsexed one hundred and fifty agrited Anak finisher broiler chicks at 4 weeks of age. They were divided into 5 treatment groups of 30 broilers each and each treatment was subdivided into 3 replicates of 10 broilers each. Each replicate was housed in a pen. The broilers were weighed individually at the beginning of the experiment and their average initial weight and sex balanced and weighed weekly thereafter for determination of their growth performance. The broilers were assigned the experimental finisher diets using completely randomized design for 4 weeks. Both water and feed were given adlibitum.

Carcass evaluation

At the end of the feeding trial, two (2) birds from each treatment were randomly selected, starved of feed but not water for 24 hours, weighed and slaughtered for the determination of the following; internal organ weights (hearts, liver, kidney, spleen, lungs), cut part weights (thigh muscle, wings, back cut, drumstick and breast muscle), abdominal fat and dressed weight. The internal organs weights were expressed as percentage of the live weights

Data collection

Parameters determined were initial liveweight, final live weight, body weight gain, feed intake, dressed weight, feed conversion ratio, internal organ weight, cut parts weights and cost of production.

Data analysis

The data were subjected to one way Analysis of variance (ANOVA) according to Snedecor and Cochran (1989), where significant treatment effects were detected from the ANOVA, means were separated using Duncan's New Multiple Range test (Steel and Torrie, 1980).

Results and Discussion

Table 2: Anti-nutrient composition of raw and fermented cocoyam tuber meal *(Xanthosoma sagittifolium)*

Parameters	Raw Cocoyam Tuber	Fermented Cocoyam Tuber	SEM
Cyanide (mg CN/g)	1.30	0.15	0.41
Phytic acid (%)	54.74	51.70	1.08
Tannin (%)	1.51	0.14	0.49
Saponin (%)	26.42	23.30	1.12
Oxalate (%)	12.30	11.01	0.46

Anti nutrient content of raw and fermented cocoyam tuber meal are shown in (Table 2). The cyanide content of the raw cocoyam *(Xanthosoma sagittifolium)* was high but fermentation in water for 4 days and oven drying helped to reduce it from 1.30 mg CN/g in the raw tubers to 0.15 mg CN/g in the fermented cocoyam tuber meal. There were no significant difference ($P<0.05$) in the phytic acid, saponin, oxalate content of both the raw and fermented cocoyam tuber meal but numerically there were differences in the anti nutrients content of both the raw and fermented tubers. The tannin content in the raw cocoyam tubers were also reduced by fermentation (Table 2). This reaffirmed the earlier work by Anyaegbu *et al. (*2012) that four-days fermentation duration produced better results and would be preferred for reduction of cyanide in tuber crops like cassava and cocoyam. The tannin content of the cocoyam tubers was also reduced from 1.51% to 0.14% by fermentation. This also showed that fermentation was very effective for reducing the tannin content of the cocoyam tubers as well. The acidity factors due to the presence of oxalate are reduced by peeling, grading, soaking and fermentation operation during processing (FAO 1990). It therefore follows that diets based on fermented cocoyam tuber meal as source of energy could contain very little trace of cyanide, tannin, oxalate, saponin and phytic acid.

Table 3: Proximate composition of raw and fermented cocoyam tuber *(Xanthosoma sagittifolium)*

Parameters	Raw Cocoyam Tuber	Fermented Cocoyam Tuber	SEM
Moisture (%)	58.05	19.15	30.66
Ash (%)	3.95	1.30	0.94
Crude Protein (%)	5.43	3.56	0.66
Crude Fiber (%)	9.72	5.30	1.11
Ether Extract (%)	3.1	1.9	0.43
NFE (%)	59.79	25.48	12.17

Proximate composition of raw and fermented cocoyam tuber meal *(Xanthosoma sagittifolium)* is shown in (Table 3). There were significant differences ($P<0.05$) in the percent moisture and crude fiber of both the raw and fermented cocoyam tuber meal. The moisture and crude fiber content of the raw cocoyam tubers were high but fermentation and drying reduced them lo tolerable levels. There were no significant difference ($P>0.05$) in the percent ash, crude protein, ether extract and NFE of both the raw and fermented cocoyam tuber meal.

Performance of Finisher Broilers

Table 4: Performance of the Finisher Broilers fed the Experimental Diets

Parameters	Diet 1 (control)	Diet 2 25%FCYM	Diet 3 50%FCYM	Diet 4 75%FCYM	Diet 5 100%FCYM	SEM
Initial body wt.(g)	388.33	390.00	388.33	368.33	368.33	4.51
Finial body wt.(g)	1.98^{ab}	2.05^{a}	2.00^{b}	1.90^{ab}	1.84^{ab}	0.03
Body wt. gain (kg)	1.59^{ab}	1.66^{a}	1.61^{ab}	1.53^{b}	1.47^{c}	0.03
Daily body wt. gain(g)	56.79^{b}	59.29^{a}	57.50^{b}	54.64^{C}	52.50^{C}	1.05
Daily feed intake (g)	120.00	100.00	104.00	106.00	101.00	3.23
Feed conversion ratio	2.10^{c}	1.69^{a}	1.81^{ab}	1.94^{b}	1.92^{b}	0.06

[abc] Means within the same row with different superscripts are significantly difference (P<0.050

Feed intake

The average feed intake of the experimental groups were significantly different ($p<0.05$) and were 120.00g, 100.00, 104.00g, 106.00g and 101.00g for the control diet, diet 2, diet 3, diet 4 and diet 5, respectively as shown in Table 4. The finisher broilers on 25% FCYM, 50% FCYM, 75% FCYM and 100% FCYM recorded similar daily feed intake which were significantly ($p<0.05$) different from those on the control diet (diet 1). The finisher broilers on diet 1 (control diet) recorded significantly ($p<0.05$) the highest feed intake of 120g.

Body weight gain

In the finisher feeding trial, the broilers on 25% FCYM recorded the highest body weight gain which was significantly different ($p<0.05$) from those on the control diet (diet 1). The bodyweight gain of the groups on the control diet and diet 3 (50% FCYM) were similar and higher than those on diet 4 and diet 5.

The feed intake and body weight gain of the finisher broilers agreed with the findings of (Anyaegbu *et al*. 2012) who confirmed that four days fermentation duration produced better result and would be preferred for reduction of cyanide in tubers like cassava and cocoyam.

Feed conversion ratio

The feed conversion ratio of the finisher broilers were 2.10, 1.69, 1.81, 1.94 and 1.92 for, respectively. Significant differences (p<0.05) existed among the groups in their feed conversion ratio. The finisher broilers on 25% FCYM recorded best feed conversion ratio of 1.69 which was significantly (p<0.05) better than those on the control diet. The feed conversion ratio of the groups on diets 4 and 5 were similar and also significantly (p<0.05) better than those on the control diet.

Table 5: Proximate composition of experimental finisher broiler diets

Parameters	Diet 1 (Control Diet)	Diet 2 25%FCYM	Diet 3 50%FCYM	Diet 4 75%FCYM	Diet 5 100%FCYM
Moisture (%)	9.83	11.30	11.85	12.40	12.96
Ash (%)	7.09	8.20	8.50	9.15	9.70
CP (%)	20.37	18.56	18.15	17.13	16.35
CF (%)	4.05	3.42	3.05	2.80	2.60
EE (%)	6.15	9.30	10.20	11.25	12.20
NFE (%)	52.51	49.22	48.25	47.27	46.19

CP= Crude Protein, CF= Crude Fiber, EE = Ether Extract, NFE= Nitrogen Free Extract

Cut part weight of the experimental finisher broilers

The percentage cut part weight of the experimental finisher broilers are shown in Table 6. There were significant differences (p<0.05) in drum stick, shank, head, wing cack and neck in birds fed the different test diets . The finisher broilers on diet 3 (50%FCYM) yield the highest percent breast muscle while those on diet 2 (25% FCYM) and diet 4 (75% FCYM) yielded the lowest.

Table 6: Cut part weights of experimental finisher broiler chicken

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diets	SEM
%Thigh	9.83^{b}	9.87^{b}	8.70^{C}	10.64^{a}	9.97^{b}	0.28
%Drum Stick	9.27	8.99	8.11	9.60	9.04	0.22
%Shank	4.85	4.88	4.66	5.03	5.28	0.09
%Breast Muscle	15.00^{ab}	12.25°	16.62^{a}	13.98^{C}	16.24^{b}	0.71
%Head	2.70	3.04	2.86	3.15	3.10	0.07
%Wing	7.54	7.53	7.60	7.86	7.89	0.07
%Back Cut	12.50	12.90	13.19	11.79	10.87	0.37
%Neck	5.46	5.40	3.81	4.59	5.82	0.32

^{abc}Means on the same rows with different superscripts are significantly different (p<0.05)

Internal organ weight

The percentage internal organ weights of the experimental finisher broilers are shown in Table 7. The weights of the organs (liver, gizzard, heart, kidney, spleen, large intestine, small intestine, lungs, crops, proventriculus etc) of the birds were not affected by the treatments (p<0.05). The finisher broilers on the control diet (diet 1) and diet 2 (25% FCYM) accumulated significantly (p<0.05) more abdominal fat than others indicating higher efficiency of the birds in converting the carbohydrates of the diets into fat.

Table 7: Internal organ weight of the experimental finisher broilers

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	SEM
Live weight (kg)	1.79	1.58	1.63	1.38	1.33	0.08
Dressed wt (kg)	0.90	1.09	1.11	0.86	0.75	0.06
% Dressed wt	50.28	68.99	68.10	62.32	56.39	3.17
% Liver	3.43	2.82	2.71	3.20	3.93	0.20
% Gizzard	2.57	2.35	2.11	3.28	2.58	0.17
% Heart	0.67	0.67	0.53	0.51	0.57	0.03
% Spleen	0.14	0.17	0.15	0.21	0.17	0.01
% Abdominal fat	1.46[a]	1.06[a]	0.24[C]	0.57°	1.01[b]	0.19
% Large intestine	1.19	1.08	2.34	0.80	0.92	0.25
% Small intestine	0.31	0.37	0.42	0.45	0.47	0.03
% Proventriculus	0.73	0.66	0.79	0.80	0.71	0.02
% Kidney	0.55	0.68	0.55	0.71	0.35	0.06
% Lungs	0.68	0.44	0.41	0.61	0.52	0.05
% Crop	3.90	1.58	2.54	1.12	0.90	0.49

[abc] Means on the same rows with different superscripts are significantly different ($p<0.05$)

Percentage dressed weight

The finisher broilers on diet 2 (25%FCYM) recorded significantly ($p<0.05$) the highest percent dressed weight of 68.99 followed by those on diets 3, 4, 5 and the least was the control diet (50.28%).

Economics of the of production of finisher broilers fed the experimental diets

The cost of production per kg of cocoyam based finisher broiler diet was cheapest for diet 5 (100% FCYM) (₦70.46) while the costliest were those on diet 1 (maize based diet). The cost of production per kg of finisher broilers wascost liest for diet 1 (25%FCYM) ₦346.69 and the cheapest was those on diet 5 (100% FCYM) ₦135.28, diet 5 (100% FCYM) (₦135.28).

Table 8: Economics of Broiler Finisher Experimental Diets

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	SEM
Cost/kg Feed	173.66	147.88	122.06	96.26	70.46	16.32
Cost of production/kg Broiler (₦)	346.69	249.92	220.93	186.74	135.28	-

Conclusion

It was concluded that four days fermentation duration of cocoyam tubers *(Xanthosoma sagitlifolium)* for processing broiler diets was quite an effective method of processing cocoyam tuber meal for use in finisher broilers because fermentation reduced the cyanide, tannins, oxalate and saponin contents of the cocoyam tubers to a tolerable levels for the broilerchickens as illustrated in this experiment.

It was concluded that fermented cocoyam *(Xanthosoma sagittiflolium)* could be used in the diets finisher broilers up to 25%FCYM and performed better than those on maize based diet (control diet). Fermented cocoyam tuber meal could be used in the diet of finisher broilers up to 100% without affecting body weight gain, feed intake and feed conversion ratio as indicated in this study.

Recommendations

It is therefore recommended that large scale production of tannia cocoyam (*Xanthosoma sagitifolium)* for poultry feeding should be encouraged so as to reduce the pressure of demand on maize. This may help to reduce the cost of poultry production and hence the cost of poultry products, eggs and poultry meat.

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Received: 13th October, 2017
Accepted: 1st March, 2018