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REGULAR ARTICLES

Performance and economy of production of broilers fed Siam weed (*Chromolaena odorata*) leaf meal (SWLM)

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Abstract

A 49-day feeding trial was conducted to determine the effect of Siam weed leaf meal (SWLM)-based diets on growth, organ, and carcass weight characteristics and economics of production of broilers. Proximate biochemical composition of SWLM and the appropriate inclusion level of SWLM for optimum productivity were also determined. Ninety-six-day-old Chi broiler chicks were randomly divided into 4 groups of 24 birds, and each group replicated three times. Each group was assigned to one experimental diet in a completely randomized design marked T1 (0%), T2 (4%), T3 (8%), and T4 (12%). Proximate biochemical results revealed that SWLM is rich in protein (20.52%) and minerals (9.29%). Birds on diets T1 and T2 had similar ($p > 0.05$) final live weights (FLW), which were higher ($p < 0.05$) than those on diets T3 and T4. Birds on diet T2 had the highest ($p < 0.05$) daily feed intake (DFI) and daily weight gain (DWG), while birds on diet T1 had the best feed conversion ratio (FCR) followed by birds on diet T2. The result of quadratic model regression analyses showed that SWLM levels of 1.48, 1.50, 1.47, and 1.56% supported optimum final live weight, DFI, DWG, and FCR. There were no significant ($p > 0.05$) differences in the dressing percentage, but there were significant differences in the carcass weight between birds on diet T4 and the other three diets. Similarly, pancreas and spleen had similar ($p > 0.05$) weights across the treatments. There was significant difference ($p < 0.05$) between birds on diets T1 and T4 in gizzard weight. Cost-benefit ratio was influenced ($p < 0.05$) with T4 birds having better income of US$1 per US$10.18 invested. It is concluded that SWLM is rich in essential nutrients and therefore suitable for inclusion in broiler diets at level not beyond 2% for best final live weight, daily weight gain, and thigh weight.

Keywords Alternative feedstuff · Poultry · Growth · Carcass and organ characteristics

Introduction

The demand for animal products (egg and meat) in developing countries of the world is on the increase, and this pattern is expected to continue over the years. According to FAO (2015), Nigerians consume less animal protein against its recommended value of 35 g of animal protein per day. This short fall in animal protein intake among Nigerians and as in other developing countries could be mitigated through the production of animals with short generation interval (Jiwuba et al. 2016a, 2016b) such as broilers. At the moment, poultry products are considered as luxury by a large number of people living in the developing countries. This is greatly due to high cost of poultry meat and eggs, which is controlled by the high cost of conventional protein and energy feedstuffs. This problem of high cost of feed ingredients has called for an urgent search for cheap and readily available local feedstuffs such as leaf and seed meal of tropical plants among poultry researchers.

Siam weed (*Chromolaena odorata*), one of such leaf meal, is a perennial shrub which belongs to the family Asteraceae. Siam weed is called *Acheampong* in Ghana and in Nigeria; it is referred to as *Obiarakara*, *Inini Eliza*, *Osiwumuo*, *or Diochie* in eastern part of Nigeria while in the western part, it is called *Ewe Awolowo*. Siam weed plant which is usually

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uprooted from the farm land during land clearing has been reported to be rich in energy, protein, vitamin (oxycarotenoids), and minerals (Apori et al. 2000; Anyaechie and Onifade 2000). Studies have shown that Siam weed contain anti-nutritional factors such as saponins, phytates, tannins, and cyanogenic glycosides (Apori et al. 2000; Fasuyi et al. 2005; Igboh et al. 2009). Phytic acid has been reported to bind calcium, zinc, iron, and other minerals, thereby reducing their availability in the body (FAO 1990). Saponins reduce the uptake of certain nutrients including glucose and cholesterol at the gut through intra-lumenal physicochemical interaction. However, the anti-nutrient contents of feeds according to FAO (1990) are reduced by a number of processing methods including cooking, toasting, and drying. Siam weed has also been reported to have multipurpose medicinal properties (Phan et al. 2001). Nutrient composition of SWLM (Akinmitimi 1992; Fasuyi et al. 2005; Igboh et al. 2009) and its feeding value for laying birds (Fasuyi et al. 2005; Ekenyem et al. 2009) and rabbits (Akinmutimi and Akufo 2006) have been documented, but not much have been reported on the use of SWLM as a feed ingredient source for poultry, especially as a component of broiler diet and its effect on performance and economics of production. This study therefore aimed to determine the effect of Siam weed leaf meal on growth, carcass, and organ characteristics and economics of production of broilers.

Materials and methods

The experiment was carried out at the Poultry Unit, Federal College of Agriculture, Ishiagu, Ebonyi State, Nigeria. The College is located at about 3 km away from Ishiagu main town. The College is situated at latitude 5.56° N and longitude 7.31° E, with an average rainfall of 1653 mm and a prevailing temperature condition of 28.50 °C and relative humidity of about 80%. Fresh leaves of Siam weed plants without flowers were harvested within the College. Thereafter, the leaves were shade dried for 4 days until they became crispy while retaining the greenish coloration. The dry leaves were milled using a hammer mill to produce leaf meal before they were incorporated into the diets. Four broiler diets (Table 1) designated as T1, T2, T3, and T4 were formulated to contain 0, 4, 8, and 12% levels of SWLM.

Ninety-six-day-old chicks were sourced from Chi farms® in Ibadan. They were randomly assigned to four treatment groups of 24 birds each. Each treatment group was replicated three times with eight birds constituting a replicate. The four treatment groups were fed the four experimental diets in a completely randomized design for 49 days. Each replicate was housed in a concrete floor covered with wood shavings as the litter material. The birds were stabilized for 14 days before the commencement of the study in line with the permission and guidelines of research policy of the College's Animal Ethics Committee. Before the arrival of the day-old chicks, the brooding house was swept, washed, disinfected, and allowed to dry. The brooder house was pre-heated for 6–12 h to enable it to reach the normal temperature (32 °C) required by a day-old chick. Feed and water were provided ad libitum. Heat and light were provided for the first 14 days with stoves and electric bulbs. The birds were vaccinated against infectious bursal (Gumboro) disease at days 10 and 24, respectively, while the NDV-Lasota vaccine was given on days 1, 14, and 28 to protect the birds against Newcastle disease. Initial live weights of the animals were taken at the beginning of the feeding trial and weekly thereafter. Final live weight was obtained by weighing the birds at the end of the experiment. Daily weight gain, daily feed intake, and feed conversion ratio were calculated. At the end of the experiments, one bird per replicate was randomly selected, starved from feed for 12 h, and slaughtered for defeathered, carcass, and organ weight determination. Carcass weight was calculated by removing the head, lower shank bones, and internal organs from the defeathered weight. Dressing percentage is calculated as the percentage of the carcass weight to the final live weight. The internal organ weight and weight of the cut parts were expressed as percentage of carcass weight.

The prevailing market prices of the feed ingredients at the time of the experiment were used to estimate the unit cost of the experimental diet (N430 = $1 at the time of the experiment). The variable costs of feeding the birds considered the

Table 1 Composition of the experimental broiler diets with varying inclusion of SWLM

Ingredients	T1	T2	T3	T4
Maize	55.00	53.00	51.00	55.00
Wheat offal	10.00	9.00	8.00	3.00
Soya bean meal	28.55	27.55	26.55	23.55
SWLM	0.00	4.00	8.00	12.00
Fish meal	2.00	2.00	2.00	2.00
Bone meal	2.00	2.00	2.00	2.00
Limestone	1.00	1.00	1.00	1.00
Premix*	0.35	0.35	0.35	0.35
Common salt	0.25	0.25	0.25	0.25
Lysine	0.35	0.35	0.35	0.35
Methionine	0.50	0.50	0.50	0.50
Total	100	100	100	100
Calculated analysis				
Crude protein (%)	20.87	20.02	20.23	19.60
ME (kcal/kg)	2931.68	2920.18	2911.65	2901.30

*Vitamin and mineral premix contributed the following to each kilogram of diet: vitamin A 500 IU, vitamin D 1500 IU, vitamin E 3 IU, vitamin K 2 mg, riboflavin 3 mg, pantothenic acid 6 mg, niacin 15 mg, vitamin B_{12} 0.8 mg, choline 3 mg, folic acid 4 mg, manganese 8 mg, zinc 0.5 mg, iodine 1.0 mg, Co 1.2 mg

Table 2 Proximate composition of the experimental diets and SWLM

Constituents	T1	T2	T3	T3	T4	SWLM
Dry matter	94.40	93.46	92.71	94.15	95.02	95.70
Crude protein	19.38	19.68	19.68	19.68	19.84	20.52
Crude fiber	4.30	4.00	4.94	4.00	4.46	5.58
Ash	15.84	18.70	19.19	19.03	19.52	9.29
Ether extract	5.25	5.45	2.45	3.85	3.90	6.10
NFE	49.63	45.79	49.45	48.59	52.28	53.94

NFE nitrogen-free extract

cost of the feeds and all other costs (i.e., labor, capital investment, and housing) were the same for all the treatments. The cost of processing the Siam weed leaf meal was included as the feed cost. Feed cost (US$) per kilogram, cost per kilogram of daily weight gain, and cost-benefit ratio were calculated. The cost-benefit ratio was determined by dividing cost/kg live weight with feed cost/weight gain. Cost/kg diet was US$ 0.25, 0.10, 0.99, and 0.94 for groups T1, T2, T3, and T4, respectively. Proximate analysis of different experimental diets and that of the test ingredient was carried out at the College of Animal Science and Animal Production, Michael Okpara University of Agriculture, Umudike, Animal Nutrition Laboratory, using the methods (AOAC 2000). The results were analyzed with the general linear model (GLM) procedures of Special Package for Social Sciences (SPSS 17.0). Optimal responses in final live weights (FLW), daily feed intake (DFI), daily weight gain (DWG), and feed conversion ratio (FCR) of broilers to the dietary SWLM level were modeled using the following quadratic model: $Y = a + b_1x + b_2x^2$, where Y = FLW, DFI, DWG, and FCR, a = intercept; b_1 and b_2 = coefficient of the quadratic equation; x = dietary SWLM level and $b_1/2b_2 = x$ value for optimum response.

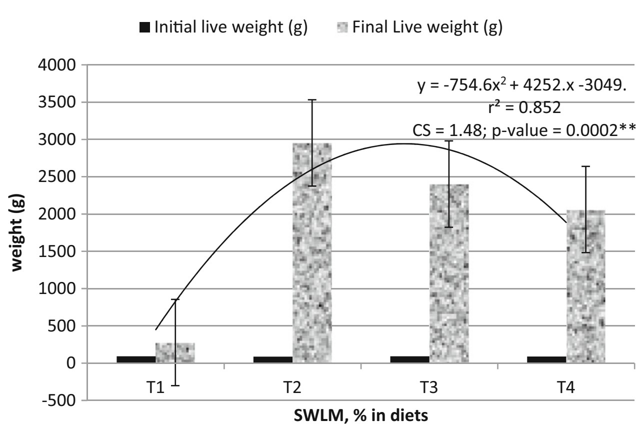

Fig. 1 Final and initial live weight (g) patterns of broilers fed SWLM in their diets. r^2 regression coefficient, P probability, ns not significant; *significant; **highly significant; CS SWLM supplementation (%) for optimal variable

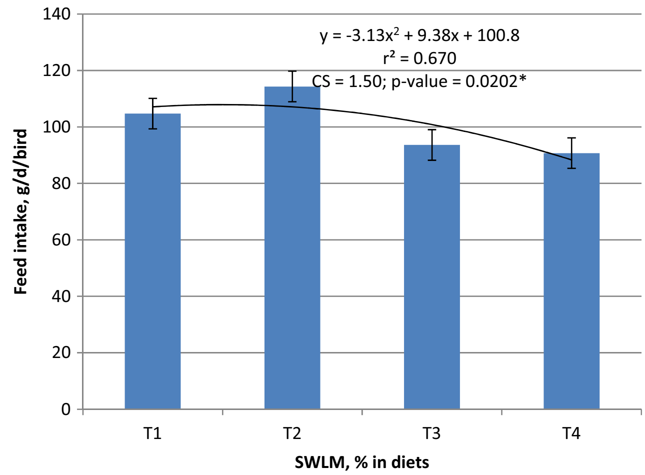

Fig. 2 Daily feed intake (g/day/bird) of broilers fed SWLM in their diets

Results and discussion

The proximate compositions of the experimental diets and SWLM are presented in Table 2. The proximate analysis of SWLM revealed a high dry matter value of 95.70%, which was higher than the value of 85.00–89.51% earlier reported (Akinmutimi and Akufo 2006). The crude protein (20.52%) and crude fiber (5.58%) obtained in this present study for SWLM are an indication that SWLM is rich in protein and low in fiber. This is similar to the results of Ekenyem et al. (2009). The relative low crude fiber (CF) makes this leaf meal a potential feed stuff for non-ruminants (Onyimonyi and Onu 2009). The high ash content of SWLM in the current study is an indication of high mineral profile in Siam weed. This value compared favorably with the ash value of 9.50 and 9.64% reported for the same leaf meal by Ekenyem et al. (2009) and Akinmutimi and Akufo (2006), respectively.

The initial and final live weights of broilers fed SWLM in their diets are presented in Fig. 1. Birds on diets T1 and T2 had

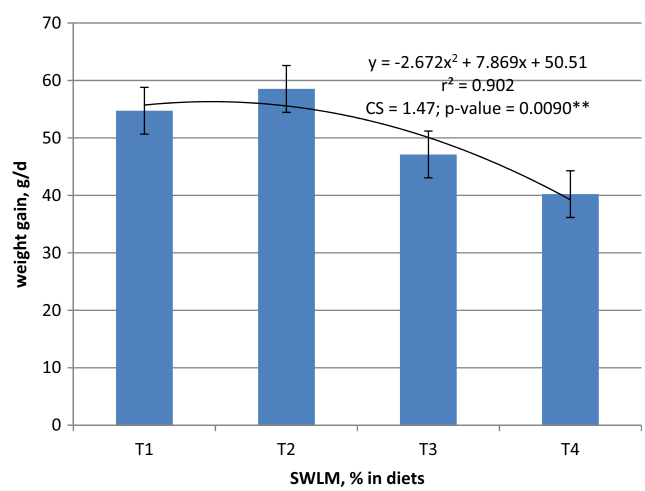

Fig. 3 Daily weight gain (g/day) characteristics of broilers fed SWLM in their diets

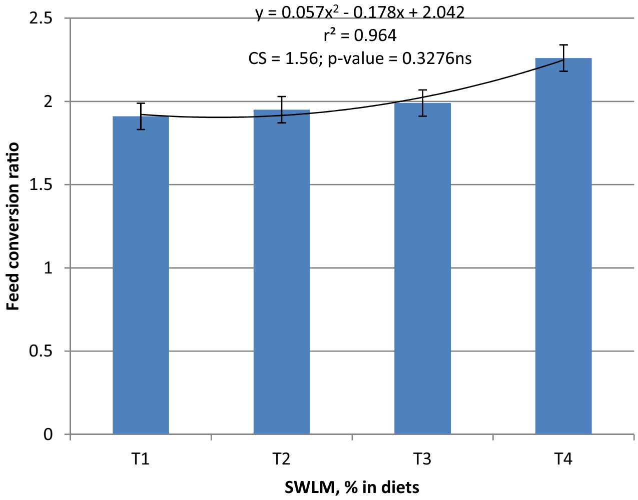

Fig. 4 Feed conversion ratio of broilers fed SWLM in their diets

similar ($p > 0.05$) final live weights, which were significantly higher ($p < 0.05$) than those on diets T3 and T4. The daily feed intake value of broilers fed T3 and T4 diet is significantly ($p < 0.05$) lower than those on diets fed T1 and T2 (Fig. 2). Also, the daily weight gain (g/day/bird) of broilers on diets T3 and T4 is significantly ($p < 0.05$) lower than those on diets T1 and T2 (Fig. 3). The observed increase in daily weight gain of birds on diet T2 could be attributed to better detoxification of the anti-nutrient factors contained in SWLM (Akinmutimi and Akufo 2006) which are known to cause growth depression in broilers. Birds on T1 diet had the best FCR followed with birds on diet T2 (Fig. 4). The FCR reported in the current study is in harmony with the findings of Opara (1996) in broilers fed *Alchornea cordifolia* leaf meal-based diets. Figures 1, 2, 3, and 4 showed that FLW was optimized at dietary SWLM level of 1.48% ($r^2 = 0.905$), DFI at 1.50% ($r^2 = 0.670$), DWG at 1.47% ($r^2 = 0.902$), and FCR at 1.56% ($R^2 = 0.964$).

The results of the carcass weight characteristics of broilers fed SWLM-based diets are presented in Table 3. Birds in T1 and T2 produced similar ($p > 0.05$) defeathered weight, which differed significantly ($p < 0.05$) from those in T3 and T4. Birds on diet T4 had significantly ($p < 0.05$) lower carcass weight compared to birds on the other three diets. There was no significant effect ($p < 0.05$) of SWLM-based diets on drumstick weight, breast muscle weight, and dressing percentage. The significant differences observed in the carcass weight in broilers fed diets T2 and T4 are in agreement with the earlier results of Onunkwo and George (2015) in broilers fed Moringa leaf meal. The carcass weight ranged 1383.30–2033.30 g and this corroborated the earlier results of Okorie et al. (2011) and Aderinola et al. (2013) in broilers fed cassava and Moringa leaf meals. The significant decrease in carcass weight of broilers on T4 could be attributed to the impaired utilization of nutrients as shown in FCR (Fig. 4). Similarly, birds on diet T4 had significantly ($p < 0.05$) lower thigh weight when compared to birds on diet T2. There was significant difference ($p > 0.05$) between birds in T1 and those in the other treatments in back weight, while birds in T3 had higher ($p < 0.05$) shank weight than birds in T1 and T2. However, the yellow shank observed with increasing level of SWLM could be attributed to oxycarotenoids which abound in SWLM and leaf meals (Opara 1996). There was significant difference ($p > 0.05$) between T1 and T4 birds in neck weight, while T2 had significantly ($p < 0.05$) higher wing weight than T4. The results of the quadratic model regression analyses of the effect of SWLM on carcass weight characteristics of broilers are presented in Table 4. SWLM inclusion level at 1.54% ($r^2 = 0.862$), 1.77% ($r^2 = 0.955$), 1.94% ($r^2 = 0.973$), 0.47% ($r^2 = 1.0000$), 2.11% ($r^2 = 0.639$), 7.51% ($r^2 = 0.386$),

Table 3 Carcass weight characteristics of broilers fed Siam weed leaf meal

Parameters	T1	T2	T3	T4	SEM
Final live weight (g)	2771.00^{a}	2952.00^{a}	2399.00^{b}	2057.00^{c}	100.38
Defeathered weight (g)	2033.30^{a}	2233.30^{a}	1733.30^{b}	1483.30^{c}	74.69
Carcass weight (g)	1566.70^{ab}	1700.00^{a}	1433.3^{ab}	1150.00^{c}	52.48
Dressing percentage (%)	56.54	57.58	59.75	55.91	1.88
Cut parts (% carcass weight)					
Thigh	14.07^{ab}	14.27^{a}	14.07^{ab}	12.33^{b}	0.88
Drum stick	13.44	14.07	12.84	12.67	0.53
Breast muscle	18.67	21.71	18.67	16.58	1.26
Back	21.85^{a}	21.22^{a}	20.27^{a}	19.00^{b}	0.08
Wing	12.03^{ab}	14.83^{a}	11.6^{ab}	10.67^{b}	0.61
Shank	4.69^{c}	4.20^{bc}	5.97^{a}	5.33^{ab}	0.19
Neck	7.98^{a}	6.79^{ab}	6.30^{ab}	5.66^{b}	0.36
Head	4.37	4.57	4.75	5.00	0.5

Means within the same row with different superscript letters are significantly different ($p < 0.05$)

Table 4 Effect of SWLM diets on carcass characteristics of broilers

Parameters	Formula	CS	r^2	p value
Defeathered weight (g)	$Y = 1845 + 347.5x - 112.5x^2$	1.54	0.862	0.00540**
Carcass weight (g)	$Y = 1320 + 369.0x - 104.1x^2$	1.77	0.955	0.00307**
Thigh	$Y = 12.61 + 1.883x - 0.485x^2$	1.94	0.973	0.00151**
Back	$Y = 22.16 - 0.15x - 0.16x^2$	0.47	1.000	0.00945**
Wing	$Y = 9.447 + 3.931x - 0.932x^2$	2.11	0.639	0.00319**
Shank	$Y = 3.937 + 0.556x - 0.037x^2$	7.51	0.386	0.03676*
Neck	$Y = 9.232 - 1.432x + 0.137x^2$	5.23	0.987	0.02061*

R^2 regression coefficient, *P* probability, *ns* not significant at $p > 0.01$; 0.05, *CS* SWLM supplementation (%) for optimal variable

*Significant

**Highly significant

and 5.23% ($r^2 = 0.987$) supported optimum defeathered weight, carcass weight, thigh weight, back weight, wing weight, shank weight, and neck weight. The coefficient of determination r^2 for final live weight, carcass weight, thigh weight, and back weight is regarded as been high. This implies that high level of SWLM has greater influence in increasing the final live weight, carcass weight, thigh weight, and back weight.

The results of the organ weight characteristics of broiler fed different levels of SWLM are presented in Table 5. There were no significant differences ($p > 0.05$) among the treatments in pancreas and spleen weights. Birds on diet T4 had significantly higher ($p < 0.05$) gizzard weight than those on diet T1, but similar to those on diets T2 and T3. The significant increased weight of the gizzard on diet T4 corroborates Ologhobo and Alaka (2003) who reported that larger organs are attributed to anti-nutritional factors. Liver weights of the birds on diets T1, T2, and T4 were significantly ($p < 0.05$) lower than those on diet T3. The significant decrease in the weight of the liver at T4 could be attributed to increased detoxification carried out in the liver (Ukachukwu 2000). This means that birds on diet T4 may have contained certain level of toxicity. Birds on diets T1, T3, and T4 produced similar ($p > 0.05$) heart weights, while those on T2 recorded significantly ($p < 0.05$) higher heart weight. Similarly, birds on T1 recorded significantly higher ($p < 0.05$) lung weights than those on T2 and T4. However, birds on diet T3 had similar lung weights with those on diets T1 and T2. The results of the quadratic model regression analyses of the effect of SWLM on organ weight characteristics of broiler are presented in Table 6. SWLM inclusion levels of 4.62% ($r^2 = 0.982$), 2.45% ($r^2 = 0.412$), 2.59% ($r^2 = 0.389$), and 8.00% ($r^2 = 0.764$) supported optimum gizzard, liver, heart, and lung weights. The coefficient of determination R^2 for gizzard weight is regarded as been high. This implies that high level of SWLM has greater influence in increasing the gizzard weight.

The cost of production per 100 kg feed differed ($p < 0.05$) significantly across the treatment groups and tended to decrease with increasing levels of SWLM inclusion in the diets (Table 7). Cost of production per kilogram of feed also differed ($p < 0.05$) among the treatment groups. As the level of inclusion of SWLM in the diets increased from 0% (T1) to 12% (T4), the feed cost/kilogram for each treatment group decreased. The values for feed cost per daily weight gain were lowest for the broilers fed T4 diet (US$0.23); however, this unit cost differed ($p < 0.05$) significantly from the values recorded on broilers fed diets T1 and T2. Cost-benefit ratio showed significant ($p < 0.05$) differences with birds on diet

Table 5 Organ characteristics of broilers fed Siam weed leaf meal

Parameters	T1	T2	T3	T4	SEM
Gizzard	4.46[b]	4.82[ab]	5.05[ab]	5.67[a]	0.18**
Liver	2.30[b]	2.28[b]	2.53[a]	2.19[b]	0.02*
Spleen	0.25	0.15	0.14	0.10	0.03
Pancreas	0.29	0.34	0.37	0.41	0.03
Heart	0.59[b]	0.71[a]	0.62[b]	0.63[b]	0.04**
Lungs	0.64[a]	0.55[b]	0.58[ab]	0.48[c]	0.03**

Means within the same row with different superscript letters are significantly different ($p < 0.05$)

Table 6 Effect of SWLM diets on organ characteristics of broilers

Parameters	Formula	CS	r^2	p value
Gizzard (g)	$Y = 4.36 + 0.061x - 0.065x^2$	4.62	0.982	0.0001**
Liver (g)	$Y = 1.945 + 0.392x - 0.08x^2$	2.45	0.412	0.0341*
Heart (g)	$Y = 0.492 + 0.140x - 0.027x^2$	2.59	0.389	0.02164*
Lungs (g)	$Y = 0.662 - 0.032x - 0.002x^2$	8.00	0.764	0.0005**

R^2 regression coefficient, *P* probability, *ns* not significant, *CS* SWLM supplementation (%) for optimal variable

*Significant

**Highly significant

Table 7 Cost/benefit evaluation of broilers fed graded levels of Siam weed leaf meal

Parameters	T1	T2	T3	T4	SEM
Cost/100 kg (US$)	24.97[a]	24.34[b]	22.94[c]	21.97[d]	0.07
Cost/kg (US$)	0.25[a]	0.10[ab]	0.99[b]	0.94[b]	0.001
Total feed consumed (kg)	5.13	5.60	4.59	4.45	0.65
Total cost of feed consumed (US$)	550.91[b]	586.10[a]	452.85[c]	420.44[d]	21.53
Total weight gain/kg (kg)	5.06	5.25	4.69	4.28	0.65
Feed cost/weight gain (US$)	0.25[b]	0.26[b]	0.22[c]	0.23[a]	0.001
Cost/kg live weight (US$)	2.33	2.33	2.33	2.33	0.00
Cost/benefit ratio	1:9.18	1:8.96	1:10.36	1:10.18	–

Means within the same row with different superscript letters are significantly different ($p < 0.05$)

T4 having the best value. This result was in agreement with the results of earlier studies by Ogundipe et al. (2003). The result demonstrated the qualitative benefits and financial returns of using SWLM diets, with T2 having the highest ratio and T3 the lowest value. This entails an expected benefit of US$1 for every US$10.18 in cost for T4 diet. This finding is in harmony with the results of Adeniji et al. (2011) who reported that inclusion of Moringa leaf meal in the diet reduces the cost of animal feed.

Conclusion

In conclusion, Siam weed leaf meal is of very good nutritional value and can be included in the broiler diet. It is recommended that inclusion level beyond 8% may not be well tolerated by the broilers for best live weight. The result of the quadratic optimization regression model revealed that inclusion of SWLM at 1.48, 1.50, 1.47, and 1.56% supported the optimum final live weight, daily feed intake, daily weight gain, and feed conversion ratio, respectively. Thus, the implication of these findings is that optimizing SWLM inclusion level in the diet of broilers will depend on the growth performance variable and could be helpful in enhancing their growth efficiency.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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