Effect of Substituting Maize with Different Levels of Sweet Potato Tuber Meal on Feed Intake, Feed Conversion Efficiency, and Growth Performance of Broiler Chicks

Tagesse Tadesse[1*], Mengistu Urge[2], and Negassi Ameha[2]

[1]College of Agriculture and Veterinary Medicine, Jimma University, P.O. Box 307, Jimma, Ethiopia
[2]College of Agriculture and Environmental Sciences, Haramaya University, P.O. Box 138, Dire Dawa, Ethiopia

Abstract

Background: Shortage of conventional energy feedstuff such as maize and significant cost of the ingredients of ration is a major constraint to poultry production in developing countries like Ethiopia. In this regard, sweet potato is a locally accessible non-conventional energy feed stuff that can be incorporated into the diets of poultry as an alternative option of energy feed.

Objective**:** A study was conducted to evaluate the effect of substituting maize with different levels of sweet potato tuber meal (SWPTM) on feed intake, feed conversion efficiency, and growth performance of broiler chicks.

Materials and Methods: One hundred ninety-two Cobb 500 broiler chick strains with initial weight of 35.64 ± 0.37 (mean ± SD) grams were randomly distributed to four treatments each with three replications in a completely randomized design. The four treatment diets used were rations containing 0% (T1), 15% (T2), 30% (T3), and 45% (T4) level of sweet potato tuber meal to substitute maize.

Results: The sweet potato tuber meal contained 8.32% crude protein (CP) and 3651 kcal kg dry matter^{-1}metabolizable energy .The average daily feed intake during the entire experimental period was 71.1, 91, 95.5 and 97.7 gram per chick (SEM = 0.77) for T1, T2, T3 and T4 respectively, and higher for T4 as compared to T1, T2 and T3 and lower for T1 as compared to the rest of the treatments ($P < 0.05$). The body weight gain during the entire experimental period was 31.35, 45.23, 35.91 and 35.39 gram per chick per day (SEM = 0.89) for T1, T2, T3 and T4 respectively, and higher for T2 as compared to T1, T3 and T4. The feed conversion ratios during the entire period were 2.21, 1.98, 2.60 and 2.7 (SEM = 0.05) for T1, T2, T3 and T4, respectively and better for T2 as compared to T1, T3 and T4.

Conclusion: Based on the results of the experiment, it can be concluded that sweet potato tuber meal at 15% levels in broilers ration diet enhanced feed intake and growth performance of broiler chicks. Based on the feed intake and growth performance of the broiler chicks, 15% graded level of SWPTM for maize in the diet is recommended according to the current study.

Keywords: Body weight gain; Cobb500; Feed conversion ratio; Root crop; Sun dried

1. Introduction

Chicken meat and eggs have been recommended to bridge the protein gap more than other species of livestock because of short generation interval, high rate of productivity, quicker turnover rate, higher feed efficiency, and low labor and land requirements (Ojedapo *et al.*, 2008). Feed cost is frequently ensnared in the significant expense of chicken items. It is assessed to address the greater part of the absolute expense of chicken production under intensive condition (Wilson and Beyer, 2000). Accordingly, feed costs account for up to 70% of total costs in typical livestock production systems and up to 69% in intensive poultry production systems (Donohue and Cunningham, 2009). In developing nations, feed shortage and significant expense of the ingredients of rations are a major constraint to poultry production. Maize, which typically forms the greater part

*Corresponding author: tagessetadesse76@gmail.com

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of such diets, has numerous different uses and may not be effectively accessible for poultry production in the future. Maize is progressively being used for human food and other industrial purposes including biofuel production and alcoholic beverages (Potter and Hotchkiss, 1995 and Dei, 2017).

Moreover, production of maize in many tropical countries has fallen relative to the rising interest in the grain because of continuous frequent drought, flood, and insect invasion that are influencing some maize-delivering regions. Consequently, relying solely on maize as the sole significant wellspring of dietary energy for the poultry business might be unsafe and an option is required (Agwunobi, 1999). Most of the developing countries have been fighting to supply satisfactory feed to their livestock, because of insufficient production of conventional ingredients for livestock feeding. Humans and livestock compete for the insufficient amounts of concentrated feedstuffs they produce yearly. Subsequently, the shortage of feed resources regularly forces a major challenge in livestock production in these countries (Aregheore, 2000). A serious problem in Ethiopia's livestock production system has been distinguished as a lack of feed in both quantity and quality (Adugna Tolera, 2009). The normal increasing expense of maize because of decreased production and its variable use require research to discover less expensive and locally accessible non-conventional energy feed stuff such as sweet potato (Ipomoea batatas LAM). Substitution of some portion of conventional corn diet with a cheaper option feedstuff like sweet potato meal is an alternative option.

Ingredient substitution in a conventional compound ration requires no only the assessment of the chickens' performance and carcass qualities but also the overall acceptability of the ingredient by the chickens (Poste, 1990). In this respect, sweet potato as the new ingredient of the ration ought to have the option to fill in for corn completely or partially and not oppositely influence the productivity of chickens. That is, it must not lessen feed intake and efficiency, growth, dressing percentage, and should not adversely influence survival and should produce a product of the same or superior quality (Ojewola *et al*., 2006). The findings of Onyekwere *et al.* (2008) revealed that including 20% of sweet potato root meal to the whole ration had no negative impact on broiler starter phase. Similarly, inclusion of 38.73% dietary sweet potato meal will enhance acceptable growth performance for Japanese quail (Edache *et al.,* 2009).

Sweet potato tuber is fit for use as feed in the poultry industry. In addition, it has low anti-nutritional factors, low fibre, and high nitrogen free extract and is highly palatable (Ravindran and Blair, 1991 and Afolayan, 2010). It can be incorporated into the diets of monogastric animals as a source of energy without any detrimental effect on their wellbeing and performance, thereby reducing the expense of feeding. Its main nutritional importance has been its starch content. However, sweet potato can also be a source of other nutritionally significant dietary factors like Vitamin A, Ascorbic corrosive, Thiamin, Riboflavin and Niacin (Dominguez, 1990). The few accessible reports agree that sweet potato can be incorporated into diets of chickens yet should not be made the sole source of energy (Tewe, 1991). The findings of Onyekwere *et al.* (2008) revealed that adding 20% of sweet potato root meal to the diet had no negative impact on broiler starter phase. Likewise, inclusion of 38.73% dietary sweet potato meal will enhance acceptable growth performance for Japanese quail (Edache *et al.,* 2009).

The potential of dried leaves of sweet potato supplementation offers enough energy and protein for optimum growth and feed conversion efficiency when used in finisher chicks ration up to a level of 10–15% of the ration and leads to significant weight gains (Tsega Wude and Berhan Tamir, 2009). Melesse Aberra *et al.* (2017) reported that partially replacing cooked soybean seed with sweet potato leaf meal in broiler diets and can be a feasible alternative in smallholder chicken production systems. Therefore, an alternative to cereals in livestock feeds might be the only immediate solution (Scott, 1995). Sweet potato roots are a good source of energy for poultry (Ravindran *et al.,* 1995). Several studies have evaluated the use of possible alternative feed ingredients; however, more widespread feed trials have to be done in order to meet the requirements set forth by the National Research Council. Various experiments have been conducted on the topic of using sweet potato vines and leaves for production chickens. They have been included in diets as a source of protein and improved the yellowish pigmentation of skins, growth rate, feed intake and feed conversion efficiency of broiler chicks (Woolfe, 1992; Farrell *et al.,* 2000 and Tsega Wude and Berhan Tamir, 2009).

Besides, there have been some accessible studies done on use of partially cooked meal of sweet potato in the diet. The inclusion of partially cooked sweet potato tuber meal did not affect the performance of chickens' in terms of daily body weight gain and feed conversion ratio (Adeduwura *et al.,* 2012). This experiment was aimed to evaluate a raw sweet potato tuber without peeling the skin as a source of energy feed ingredient to substitute maize in chicks' diet. The research was, therefore, conducted to investigate the effect of substituting maize with different levels of sun-dried sweet potato tuber meal on feed intake, feed conversion efficiency, and growth performance of broiler chicks.

2. Materials and Methods

2.1. Description of the Study Area

The experiment was conducted at Haramaya University's Poultry Farm on the main campus. The University is located at 42°3' E longitude, 9°26' N latitude, and at an altitude of about 2006 meters above sea level. The campus of the University is about 505 km far from Addis Ababa, the capital city of Ethiopia, in the easterly direction. The mean annual rainfall of the area amounts to 780 mm and the average minimum and maximum temperatures are 8 and 24 °C, respectively (Samuel Sahile, 2008).

2.2. Feed Ingredients and Experimental Rations

The feed ingredients used in the formulation of the different experimental rations of the study were maize grain, raw sun-dried sweet potato tuber meal, wheat short, noug seed cake, soybean meal, vitamin premix, methionine, lysine, salt and limestone. Sweet potato tuber was purchased from Haramaya district farmers. Whole fresh sweet potato tuber without removing skin was cleaned, washed and cut in to small pieces, then spread on plat form (canvas) under the sun and dried for one week. The dried sweet potato tuber slice was hammer-milled with the sieve size 5mm and stored until incorporation into the diets. The sun dried sweet potato tuber meal was mixed with the other feed ingredients depending on the substitution level for maize in each treatment. The treatment rations were formulated to be isocaloric and isonitrogenous to meet the nutrient requirements of starter and finisher broilers (Leeson and Summer, 2005).

Treatment rations were formulated by substituting raw sun-dried sweet potato tuber meal for maize at a graded level of 0, 15%, 30%, and 45%. Rations were formulated to contain approximately 22% and 20% CP and 3100 kcal/kg and 3200 kcal/kg ME for starter and finisher phases, respectively (NRC, 1994). The starter phase was until three weeks of age. The finisher phase covered the period from three weeks onwards up to sixth weeks of age and the respective rations were fed accordingly. The starter and finisher diets were formulated separately as indicated in Tables 1 and 2, respectively.

Table 1. Percentage proportion of ingredients used in formulating starter ration.

Ingredient (%)	Treatments			
	T1	T2	T3	T4
SWPTM	0	15	30	45
Maize	45	30	15	0
WS	7.4	8.4	6.4	7
SBM	30	31	31	31
NSC	15	13	15	14.4
Limestone	1	1	1	1
VP	0.8	0.8	0.8	0.8
Lysine	0.1	0.1	0.1	0.1
Methionine	0.2	0.2	0.2	0.2
Salt	0.5	0.5	0.5	0.5
Total	100	100	100	100

Note: *SWPTM = Sweet potato tuber meal; WS = Wheat short; SBM = Soybean meal; NSC = Noug seed cake; VP = Vitamin premix;* T_1 *= 0% of maize substituted by sweet potato tuber meal;* T_2 *= 15% of maize substituted by sweet potato tuber meal;* T_3 *= 30% of maize substituted by sweet potato tuber meal; and* T_4 *= 45% of maize substituted by sweet potato tuber meal.*

Table 2. Percentage proportion of ingredients used in formulating finisher ration.

Ingredients (%)	Treatments			
	T1	T2	T3	T4
SWPTM	0	15	30	45
Maize	45	30	15	0
WS	16.4	17	14.4	15.4
SBM	26	25	25	25
NSC	10	10.4	13	12
Limestone	1	1	1	1
VP	0.8	0.8	0.8	0.8
Lysine	0.1	0.1	0.1	0.1
Methionine	0.2	0.2	0.2	0.2
Salt	0.5	0.5	0.5	0.5
Total	100	100	100	100

Note: *SWPTM = Sweet potato tuber meal; WS = Wheat short; SBM = Soybean meal; NSC = Noug seed cake; VP = Vitamin premix;* T_1 *= 0% of maize substituted by sweet potato tuber meal;* T_2 *= 15% of maize substituted by sweet potato tuber meal;* T_3 *= 30% of maize substituted by sweet potato tuber meal; and* T_4 *= 45% of maize substituted by sweet potato tuber meal.*

2.3. Treatments and Experimental Design

The treatments consisted of one hundred ninety-two Cobb 500 broiler chick strains with initial weight of 35.64 ± 0.37 (mean ± SD) grams. These chicks were randomly distributed to four treatments. The four treatment diets used were rations containing 0% (T1), 15% (T2), 30% (T3), and 45% (T4) level of sweet potato tuber meal to substitute maize. The experiments were laid out as a completely randomized design (CRD) and replicated three times per treatment. Twelve pens were used for the one hundred ninety-two day old chicks and the chicks were randomly assigned to each pen (Table 3).

Table 3. Experimental treatments.

Treatments	Number of replication	Starter phase			Finisher phase		
		Chicks/replication			Chicks/replication		
		R1	R2	R3	R1	R2	R3
T1	3	16	16	16	15	14	14
T2	3	16	16	16	13	15	15
T3	3	16	16	16	15	15	14
T4	3	16	16	16	14	16	13

Note: *R1, R2 and R3 refer to replication one, two and three, respectively;* T_1 *= 0% of maize substituted by sweet potato tuber;* T_2 *= 15% of maize substituted by sweet potato tuber;* T_3 *= 30% of maize substituted by sweet potato tuber; and* T_4 *= 45% of maize substituted by sweet potato tuber meal.*

2.4. Management of Experimental Chicks

The experimental pens were cleaned and disinfected two weeks before the arrival of the chicks. The pens were washed down with water and sprayed with a commercial disinfectant labeled for use in the poultry farm. The feeding and drinking troughs were properly cleaned, dried and disinfected before chicks' arrival. One hundred ninety-two Cobb500 chicks were purchased from Debre Zeit poultry commercial farm. For these chicks, 12 pens were used and their floors were covered with wood shaving. Each pen was also equipped with a 250-watt heat bulb. The chicks were randomly grouped into 12 pens (16 chicks per replication) and allotted to the four treatments in three replications. The chicks were fed *ad libitum* in groups in plastic trays throughout the experimental period. Water was given by small round waterers for the first three weeks followed by normal round waterers for the remaining time of the trial period and the experiment took a total of 45 days. All health precautions were taken and appropriate disease control measures were carefully followed throughout the study period.

2.5. Chemical Analysis of Feed

Representative samples were taken from each of the feed ingredients used in the experiment and analyzed before formulating the actual treatment rations. Based on the chemical composition of the ingredients, ration formulation was done for each treatment. Samples of chemical analysis of the experimental diets containing different proportions of sweet potato tubers was done from composite sample at the end of the experiment. Samples were analyzed according to Weende or proximate analysis method (AOAC, 1990). Chemical analyses of experimental feeds were carried out for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF) and ash in animal nutrition laboratory of the Haramaya University. Nitrogen (N) content was determined by Kjeldahl procedure and crude protein (CP) was calculated as N x 6.25. Calcium and phosphorus contents were determined by atomic absorption spectrophotometer. Metabolisable energy (ME) of the experimental diets was determined by an indirect method according to the formula given by Wiseman (1987) as follows:

$$ME\ (Kcal/kgDM) = 3951 + 54.4EE - 88.7CF - 40.8Ash$$

2.6. Parameters Evaluated and Data Collection Procedure

2.6.1. Feed intake

The feed was weighed every day to determine the average feed intake per chick for the different treatment groups. Feed intake was calculated as the difference between offered and leftover feed.

2.6.2. Body weight gain (BWG) and feed conversion ratio (FCR)

The chicks were weighed at the beginning of the experiment and every week to determine the average weight gain per chick for the different treatment groups. The average daily weight gain (ADG) was determined by dividing the average body weight gain by the number of experimental days. Feed Conversion Ratio (FCR) was calculated as the ratio of average feed intake divided by average body weight gain (g).

2.7. Management of Data and Statistical Analysis

The experiment data were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of SAS (2009) version 9.2. When the analysis of variance revealed the existence of significant differences, the differences among treatment means were compared using least significant difference (LSD) test at $P < 0.05$. The model used for data analysis was:

$$Yij = \mu + Ti + eij$$

Where, Yij = an observation (experimental unit); μ = Overall mean; Ti = Treatment effect (I = 1-4); and eij = Random error term.

3. Results and Discussion

3.1. Chemical Composition of Experimental Diets

Laboratory results showed that the energy contents of sweet potato tuber meal (SWPTM) and maize were 3651 and 3650 kcal kg^{-1}, respectively (Table 4). The result revealed that the energy contents of both maize and sweet potato tubers were almost similar. This would make sweet tuber an effective energy feed with the potential to be used as a substitute for maize in broiler ration. This result is in agreement with the finding of Ravindran and Blair (1991) who reported that SWPTM contains energy that is comparable to the energy contained by maize in broiler diets. The crude protein content of SWPTM was 8.32%, which is higher than the crude protein (CP) content of about 5.07% found by Muragun *et al.* (2012) in sweet potato tuber. This variability in the content of crude protein in sweet potato tuber could be attributed to differences in the varieties of sweet potato, climatic and geological condition of area from where the sweet potato tubers originated. The laboratory DM percentage of sweet potato tuber was 95.4%, which is similar with the finding of Bartlett and Beckford (2015) who found 94.7% DM in sweet potato tuber. The fiber content of sweet potato tuber was 1.81%, which is almost similar with the finding of Apata and Babalola (2012) who noted 1.53% CF in sweet potato tuber.

Table 4. Chemical composition of feed ingredients.

Chemical composition	Ingredients				
	SWPTM	Maize	WS	SBM	NSC
DM%	95.4	90.2	89.8	94.0	93.0
CP%DM	8.32	9.0	15.0	40.6	32.5
EE%DM	0.82	5.76	3.25	8.2	5.1
CF%DM	1.81	5.45	7.29	5.9	17.9
Ash%DM	4.52	3.2	4.95	7.6	7.8
Ca% DM	0.27	0.06	0.65	0.3	0.46
P%DM	0.17	0.32	0.93	0.7	1.1
ME(Kcal/kg DM)	3651	3650	3279	3564	2323

Note: *SWPTM = Sweet potato tuber meal; WS = Wheat short; SBM = Soybean meal; NSC = Noug seed cake; DM = Dry Mater; EE = Ether Extract; CF = Crude Fiber; CP = Crude Protein = Phosphorus; Ca = Calcium; and ME = Metabolizable Energy.*

The metabolizable energy (ME) and CP contents of treatment rations within each phase were similar (Table 5), as the treatment rations were formulated to be isocaloric and isonitrogenous. The metabolizable energy values of the diets were not far from the recommended value of 3100 and 3200 kcal kg^{-1} for the starter and finisher phases (NRC, 1994) of broiler chickens, respectively.

Table 5. Chemical composition of experimental rations (% DM).

Treatments	DM%	CP (%)	EE (%)	CF (%)	Ash (%)	Ca (%)	P (%)	ME (kcal kg^{-1} DM)
Starter diet								
T1	92.7	22.2	3.1	6.0	10.5	0.8	0.5	3159
T2	92.5	22.1	3.1	6.1	10.2	0.8	0.6	3162
T3	92.6	22.3	3.0	5.9	10.4	0.9	0.7	3166
T4	92.7	22.1	3.0	5.9	10.3	0.9	0.7	3170
Finisher diet								
T1	91.7	20.3	3.2	5.8	8.0	0.8	0.6	3284
T2	91.6	20.1	3	5.7	8.0	0.7	0.6	3282
T3	91.7	20.4	3.8	5.7	9.2	0.8	0.7	3276
T4	91.9	20.1	4.0	6.0	9.0	0.9	0.8	3280

Note: *SWPT = Sweet potato tuber; WS = Wheat short; SBM = Soybean meal; NSC = Noug seed cake; DM = Dry Mater; EE = Ether Extract; CF = Crude Fiber; CP = Crude Protein; P = Phosphorus; Ca = Calcium; ME = Metabolizable Energy; T = 0% of maize substituted by sweet potato tuber meal; T2 = 15% of maize substituted by sweet potato tuber meal; T3 = 30% of maize substituted by sweet potato tuber meal; and T4 = 45% of maize substituted by sweet potato tuber meal.*

3.2. Feed Intake

The results showed that the average daily and total feed intake during the starter and finisher phases as well as for the whole experimental period was affected (P < 0.05) by the treatments (Table 6). Accordingly, substitution of maize by different levels of sweet potato tuber meal improved feed intake as compared to the control group during the starter phase. Feed intake during the finisher phase increased with the increasing level of sweet potato tuber meal in the diet. However, feed intake during the entire experiment period was higher in T3 and T4 as compared to T1 and T2, and T2 has higher feed intake than T1 showing that feed intake was increased as level of inclusion of SWPTM increased. This indicates that the sweetness of SWPTM played a positive role in improving intake of diets containing SWPTM, considering the fact that the diet without SWPTM inclusion was the least consumed during all phases. The increment in feed intake might also be due to the difference in the breed of chickens used, the difference in the varieties of sweet potato, and the various preparation techniques of the SWPTM. This result is in agreement with the findings of Afolayan *et al.* (2012) who reported a significant difference in feed intake within groups of chickens fed different substitution levels of SWPTM meal for maize in the broiler ration. Bartlett and Beckford (2015) did not note significant differences in total feed intake and daily feed intake in chicks fed on rations containing different substitution levels of sweet potato tuber meal for maize indicating sweet potato meal did not affect feed intake. Significantly higher intake in chicks fed on ration containing SWPTM in the present study compared to that reported in some literature could be an attribute of the difference in breeds of chickens used, the difference in the varieties of sweet potato, and the different preparation methods of the SWPTM.

Table 6. The effect of feeding different substitution levels of sweet potato tuber meal for maize on feed intake of broilers during the starter and finisher phases as well as the entire growth period.

Parameters	Treatments					
	T1	T2	T3	T4	SEM	P-value
Starter phase						
Total feed intake (g)	831.7[b]	1014.8[a]	1069.2[a]	1042.9[a]	45.66	0.0234
Daily feed intake (g/chick/day)	39.6[b]	48.3[a]	50.9[a]	49.6[a]	2.17	0.0234
Finisher phase						
Total feed intake (g)	2296.3[d]	2999[c]	3133.3[b]	3258.9[a]	30.00	<0.0001
Daily feed intake (g/chick/day)	99.8[d]	130.4[c]	136.2[b]	141.7[a]	1.30	<0.0001
Entire period						
Total feed intake (g)	3128[c]	4004.8[b]	4202.5[a]	4301.8[a]	33.93	<0.0001
Daily feed intake (g/chick/day)	71.1[c]	91[b]	95.5[a]	97.7[a]	0.77	<0.0001

Note: *Means within a row with different letters are significantly different at P < 0.05. SEM = Standard error of the mean; T1 = 0% of maize substituted by sweet potato tuber meal; T2 = 15% of maize substituted by sweet potato tuber meal; T3 = 30% of maize substituted by sweet potato tuber meal; and T4 = 45% of maize substituted by sweet potato tuber meal.*

3.3. Body Weight Gain

Body weight change and average daily weight gain was affected significantly ($P < 0.05$) by the treatments. Analysis of variance revealed significantly higher ($P < 0.05$) weight gain of chicks subjected to treatment two (T2) as compared to those subjected to the other treatments during the starter and finisher phases as well as during the entire period of the experiment. In finisher and entire experimental period, chicks in treatment one (T1) gained lower weight compared to treatment three and treatment four. The lower growth of chicks in treatment one (T1) might be related to the relatively lower feed intake. Reduction in the rate of growth of chicks subjected to treatment three (T3) and treatment four (T4) rations during starter and finisher phases as well as during the entire experimental period as compared to treatment two (T2) might be related to the increase in wet droppings resulting in a gradual decrease in the live weight gain. This wet dropping may indicate the laxative effect of sweet potato tuber in higher rate of replacement (Aguwobi, 1999). This laxative effect of sweet potato tuber meal may have affected feed efficiency, body weight gains and greatly reduced the abdominal fat of chicks. This could be due to the presence of some anti- nutritional factor (Agowubi, 1999 and Maphosa *et al.,* 2003) in sweet potato tuber meal that may have affected the utilization of the diet, rendering it more difficult for the chicks to convert feed into flesh and so to convert enough to deposit as fat. According to Agwunobi (1999), there was an increase in wet droppings, and a gradual decrease in live body weight gain with increased level of SWPTM. Similarly, Ayuk and Essien (2009) reported that as the level of sweet potato root meal increased, body weight and daily body weight gain decreased as compared to lower level of substitution, although it was still better than the control group.

Table 7. The effect of feeding different substitution levels of sweet potato tuber meal for maize on body weight change of broilers during the starter and finisher phases as well as the entire growth period.

Parameters	Treatments					
	T1	T2	T3	T4	SEM	P-value
Starter phase						
IBWS (g)	35.86	35.83	35.83	35.40	0.20	0.2942
FBWS (g)	419.21^{b}	448.63^{a}	414.30^{b}	394.86^{b}	8.84	0.0167
TBWGS (g/chick)	383.35^{b}	412.80^{a}	378.83^{b}	359.46^{b}	8.96	0.0188
DBWGS (g/chick/day)	18.25^{b}	19.65^{a}	18.03^{b}	17.11^{b}	0.42	0.0188
Finisher phase						
FBWF (g)	1415.17^{c}	2025.76^{a}	1615.63^{b}	1592.93^{b}	39.41	<0.0001
TBWGF (g/chick)	1031.82^{c}	1612.96^{a}	1236.80^{b}	1233.46^{b}	37.49	<0.0001
DBWDF (g/chick/day)	44.86^{c}	70.13^{a}	53.77^{b}	53.63^{b}	1.63	<0.0001
Entire Period						
FBWE (g)	1415.17^{c}	2025.76^{a}	1615.63^{b}	1592.93^{b}	39.41	<0.0001
TBWGE (g/chick)	1379.30^{c}	1989.93^{a}	1580.16^{b}	1557.53^{b}	39.42	<0.0001
DBWGE (g/chick/day)	31.35^{c}	45.23^{a}	35.91^{b}	35.39^{b}	0.89	<0.0001

Note: *Means within a row with different letters are significantly different at P < 0.05. IBWS = Initial body weight in starter phase; FBWF = Final body weight in starter phase; TBWGS = Total body weight in starter phase; DBWGS = Daily body weight gain in starter phase; IBWF = Initial body weight in finisher phase; FBWF = Final body weight in finisher phase; TBWGF = Total body weight gain in finisher phase; DBWGF = Daily body weight gain in finisher phase; IBWE = Initial body weight in entire period; FBWE = Final body weight in entire period; TBWGE = Total body weight gain in entire period; DBWGE = Daily body weight gain in entire period; and SEM = Standard error of the mean.*

3.4. Feed Conversion Ratio (FCR)

There was a significant difference ($P < 0.05$) in feed conversion ratio (FCR) among the treatments. Chicks subjected to treatment one (T1) ration possessed the lower ($P < 0.05$) FCR than those subjected to treatment three (T3) and treatment four (T4) during the starter phase. However, no statistically significant difference was detected between chicks subjected to treatment one (T1) and treatment two (T2) as well as among those subjected to treatment two (T2), treatment three (T3), and treatment four (T4) during this phase. During the finisher phase and the entire period of the experiment, FCR of the groups that consumed feed in the treatment one (T1) and treatment two (T2) were significantly lower ($P < 0.05$) than those that consumed feed in the treatment three (T3) and treatment four (T4) ps and treatment. Chicks subjected to treatment two (T2) displayed lower FCR than those subjected treatment one (T1), treatment three (T3) and treatment four (T4) during the entire period of the experiment. The results of this study showed that higher substitution level of SWPTM did not improve feed conversion ratio, and treatment two compared to treatment three and treatment four had better FCR indicating 15% sweet potato tuber meal (treatment two) inclusion as a substitution for maize is more efficient than a higher level supplementation. That was a lower feed conversion ratio for treatment two could be ascribed to better efficiency of feed utilization than for the other treatments. This finding is in agreement with that recorded by Afolayan *et al.* (2012) who reported that inclusion of sweet potato tuber meal depressed feed use efficiency resulting in decreased body gain weight.

Table 8. The effect of feeding different substitution levels of sweet potato tuber meal for maize on feed conversion ratio (FCR) of broilers during the starter and finisher Phases as well as the entire growth period.

Parameters	Treatments					
	T1	T2	T3	T4	SEM	P-value
FCRS	2.16[b]	2.45[ab]	2.83[a]	2.89[a]	0.14	0.0206
FCRF	2.22[b]	1.85[c]	2.53[a]	2.64[a]	0.06	<0.0001
FCRE	2.26[b]	2.01[c]	2.55[a]	2.76[a]	0.05	<0.0001

Note: *Means within a row with different letters are significantly different at P < 0.05. FCRS = Feed conversion ratio in starter phase, FCRF = Feed conversion ratio in finisher phase, FCRE = Feed conversion ratio in entire period, SEM = Standard error of the mean, T1 = 0% of maize substituted by sweet potato tuber meal; T2 = 15% of maize substituted by sweet potato tuber meal; T3 = 30% of maize substituted by sweet potato tuber meal; and T4 = 45% of maize substituted by sweet potato tuber meal.*

4. Conclusions and Recommendations

The results of this study have demonstrated that significant differences in feed intake, weight gain and feed conversion ratio of chicks subjected to different feed treatments of maize and sweet potato as starter and finisher phases and during the entire experiment periods. Substitution of SWPTM for maize increased daily feed intake of the broiler chicks compared to the control. Weight change and daily weight gain was affected by the treatments. Significantly, higher weight gain was recorded for treatment two (T2) as compared to the other treatments during the starter and finisher phases as well as during the entire experimental periods. Generally, the substitution of sweet potato tuber meal improved the feed intake and the growth performance of the chicks. Thus, 15% sweet potato tuber meal (SWPTM) substitution level for maize in broiler ration is recommendable based on the feed intake and growth performance of the broiler chicks. Therefore, further experiments will be carried out to determine the economic feasibility of substituting maize with different levels of sweet potato tuber meal in broiler chicks' ration.

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