Yam (*Dioscorea rotundata*) tuber waste as feed for poultry production: An alternative kitchen garbage waste management

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**ABSTRACT**

High cost of feedstuff especially maize and its major contribution of energy source between man and livestock. The study assessed the effect of yam tuber waste meal on broiler bird performance and as an alternative kitchen garbage waste. Specific objectives determined the growth performances, carcass parameters and cost benefits. The experiment lasted for 8 weeks and was conducted at the Poultry Unit of the Teaching and Research Farm, Michael Okpara University of Agriculture Umudike, Abia State, Nigeria. A total of 220-day old broiler chicks (mixed sexes) of Agric-tech were selected for the study. The diets consist of Diet 1 = 44% maize and 0% yam tuber waste meal, Diet 2 = 32% maize and 12% yam tuber waste meal, Diet 3 = 22% maize and 22% yam tuber waste meal and Diet 4 = 12% maize and 32% yam tuber waste meal, where palm kernel cake, wheat offal, soya bean meal, local fish meal, limestone, vitamin premix, fucose, methionine and salt were used to balance the diets. The feed intake was measured daily, while the weight gain, feed efficiency, efficiency of feed utilization, cost benefits and feed conversion ratio were calculated at the end of the study. The result of the weight gain, the efficiency of feed utilization, feed conversion ratio and average daily weight gain had the same significance level (p>0.05) on Diets 3 and 4, respectively, higher than those fed to the other Diets. While the total feed intake and cost benefits analysis showed significance (p<0.05) among each other, the average daily feed intake and feed efficiency were not significant (p>0.05) among treatments. The dress percentage, dress weight and liveweight were significant (p<0.05) across the treatments. Conclusively, using yam tuber waste meal in replacement for maize in broiler diets revealed no adverse effect; and could serve as an alternative for kitchen garbage waste. The study, therefore, recommends that yam tuber waste meal be included at 22 – 32% in broiler diets without deleterious effects in all parameters studied.

**Introduction**

In recent years, there has been inadequate production of major feeds for poultry production such as cereal grains, as a result of competition between man and farm animals on the available grains, followed by the high cost of feed materials (Anigbogu, 1995; Anigbogu 1996; Anigbogu, 1997a). Farm animal producers have abandoned production or scaled down their farm operations to cope with the rising cost of productivity (Anigbogu et al. 2019a; Anigbogu 1999; Anigbogu, 1997b). Recently, the fear of the future unavailability of energy feeds for use in farm animal diets has been evident in discussions at various meetings and conferences as revealed by Anigbogu and Adekule-Aghale (2013). The high cost of energy feeds indicates the importance of alternative energy sources to replace regularly used feed sources in poultry diets (Agida et al., 2019a; Agida, 2019b; Agida et al., 2020). Feeding is the single and most needed poultry production component, accounting for about 60 - 80% of the total cost of production. It is evident that, the best option is to reduce the cost of feed ingredients by using alternative feeds, such as kitchen garbage waste (KGW). This will make the wastes not get to the open dumps and landfills, and will help control environmental pollution (Anigbogu and Onyejekwe, 2012), for better economic costs and to

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make poultry production profitable. Anigbogu et al. (2019) and, Anigbogu and Chukwurah (2014) agreed that, the dependence on less competitive feed resources, such as garbage wastes, would be of immense help in animal production industries, if the ingredient is sufficiently available.

To solve the problem of kitchen garbage waste (Anigbogu and Anigbogu, 1999; Anigbogu and Uchealor, 2014), there is an urgent need to embark on massive utilization of waste as feeds, to meet today’s demand in the animal feed industry. Current research has shown that, there are a large number of untapped nutrients in garbage wastes generally, which can contribute to the Nigeria poultry industry when used, and could help increase productivity (Anigbogu et al., 2018; Anigbogu and Uchealor, 2014). Waste management practices in Nigeria especially kitchen garbage is unsustainable which posed national issues, leading to apparent environmental risk. The successful utilization of kitchen garbage waste as feedstuff, will positively impact the environment and help reduce the cost of disposals, by concerned municipal authorities in many countries, not only in Nigeria (Apata and Babalola, 2012, Anigbogu and Onyejkwe, 2012).

Starch roots and tubers are important food crops with an estimated global annual production of 836 million tonnes (FAO, 2019). Yam tuber is rich in vitamin A, B, and C, has antioxidant abilities, high in digestible fibres, and are also great source of minerals (calcium, zinc, iron, copper, potassium and magnesium. Health benefits includes; better circulation, improve bone, improve red blood cell production, and anti-inflammation properties and limit the spread of free radicals. Nigeria is accountable for over 75% of the world yam production. Rot is a major factor limiting the post-harvest life of yam tuber (Discorea rotundata), and losses can be very high. Losses due to rot make yam unappealing to consumers, the waste tubers are at zero cost. Postharvest loss as a result of poor storage. High cost of labour, low soil fertility, poor weather conditions, pest and diseases, poor storage and management techniques, poor research funding and low extension services and factors limiting yam production and availability. Yam tuber waste as part of kitchen garbage waste can be chopped or sliced, then dried, milled and used as part of a formulated feed for poultry and livestock (Anigbogu, 1997; Anigbogu, 2003).

Yam (Discorea rotundata) is among Nigeria’s staple food, as Nigeria produces about 75% of the yam population (FAO 2019). Due to post-harvest damages and poor storage facilities for root and tuber crops in Nigeria, farmers have recorded a lot of damage (Ekwe et al., 2019; Agianai et al., 2004). Post-harvest losses are exceptionally high, as a result of poor shelf life and poor storage facilities (Alumu et al., 2014; Agianai et al., 2004). Yam tuber wastes can come in various forms; peeling losses, small tubers, pest-infested tubers, as well as rotten tubers. The utilization of this waste as an alternative feed stuff can improve the value chain and waste management systems, thereby creating food security (Amanze et al., 2011; Agwunobi et al., 2002; Anigbogu and Madu-Ijeoma, 2011b). The study investigate the importance of yam tuber waste utilization as energy feedstuff for broiler chickens.

Materials and Methods
Experimental site
The experiment was conducted at the Poultry Unit of the Teaching and Research Farm, Michael Okpara University of Agriculture Umudike, Abia State and lasted 8 weeks. Umudike is located on Latitude 05°21’N and Longitude 07°33’E, at an elevation of about 112m above sea level. The location has an annual rainfall of about 177.200 per annum (April to October) and a short period of the dry season (November to March) in 148 to 155 days, with a relative humidity of about 50 – 90% and temperature range of 26.0°C with an average precipitation of 2153 mm (NRCRI Meteorological Station Umudike, 2021).

Experimental chickens and management
A total of 220 day-old-chicks (mixed sexes) of Agric-tech broilers were purchased and assigned to 4 Diets with an average group weight of 43±0.2g. The groups of 4 were randomly distributed on 12 pens of 20 birds/pen on raised floor, with wood shaving as litter material. The pen T° was maintained between 95° and 65° according to the age of the chicks, while continuous light and heat were provided on 24 hourly bases for the first 2 weeks, after which the lights were provided at night (Anigbogu and Anigbogu, 2001; Anigbogu, 1995). Then, the chicks were reared as straight-run broiler-birds for 8 weeks.

Procurement and processing of test feedstuff
350kg of the yam tuber waste used were collected from the African Yam Barn Unit of the National Root Crop Research Institution Umudike, Abia State, Nigeria. After which, they were cut into small sizes, sundried for 3 days, milled and then stored for the experimental study as reported by Anigbogu (2000), Anigbogu (2001), and Anigbogu (1997), who in a similar study used taro and tannia tuber meals as...
feeds in feeding broiler birds. Then, the dried yam tuber waste was labeled yam tuber waste meal (YTWM) as in the study.

Chemical analyses

Dry matter and ash were determined by conventional gravimetrics as adopted by Jennische and Larsson (1990); while the crude fat was determined as described by Anonymous (1993). The crude fiber and lignin were done using the detergent system and permanganate oxidation of lignin as outline by Van Soest (1992). However, starch and nitrogen-free extract were determined enzymatically with thermostable amylase and amyloglucosidase as described by Nordkvist (1989); Bengtsson and Larsson (1990). Where protein was determined by the method as described by Maynard et al. (2005) and, energies determined by using an automatic bomb calorimeter (LECO AC 300, Swedish Standard 187182) and further evaluated as described by Maynard et al. (2005). Analysis of the minerals were done with an inductively coupled plasma emission spectrometer (JY 50 P, Instrument S.A; division Jobin-Yvon, Longjumean, France) after wet ashing (Frank, 1976; Frank and Petersson, 1983). Proximate analytical checks were done using (AOAC, 2019). The nutritional compositions of the yam tuber fresh and yam tuber waste meal is presented as in the Table 1.

Experimental Diets

The experimental nutritional values were calculated based on Anigbogu (1995) and Anigbogu (2000) and the diets consist of Diet 1 = 44% maize and 0% yam tuber waste meal, Diet 2 = 32% maize and 12% yam tuber waste meal, Diet 3 = 22% maize and 22% yam tuber waste meal, and Diet 4 = 12% maize and 32% yam tuber waste meal: where palm kernel cake, wheat offal, soybean meal, local fish meal, limestone, vitamin premix, lysine methionine and salt were used to balance the diets as in Table 2.

Table 1. Nutrient composition of yam tuber waste (fresh) and yam tuber waste (meal) (%).

<table>
<thead>
<tr>
<th>Nutrient composition (%)</th>
<th>Yam tuber waste fresh</th>
<th>Yam tuber waste meal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>26.6±0.25</td>
<td>90.62±1.79</td>
</tr>
<tr>
<td>Crude protein*</td>
<td>1.94±0.09</td>
<td>8.10±2.16</td>
</tr>
<tr>
<td>Ether extract</td>
<td>0.24±0.10</td>
<td>1.03±0.09</td>
</tr>
<tr>
<td>Crude fiber</td>
<td>1.10±0.10</td>
<td>4.98±0.36</td>
</tr>
<tr>
<td>Ash</td>
<td>1.10±0.10</td>
<td>3.80±0.32</td>
</tr>
<tr>
<td>Nitrogen free extract</td>
<td>22.73±2.10</td>
<td>73.44±0.77</td>
</tr>
</tbody>
</table>

Table 2. Ingredients, nutrient composition and cost of feeds of experimental diets.

<table>
<thead>
<tr>
<th>Ingredients (%)</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow maize</td>
<td>44.0</td>
<td>32.0</td>
<td>22.0</td>
<td>12.0</td>
</tr>
<tr>
<td>Yam tuber waste meal</td>
<td>0.00</td>
<td>12.0</td>
<td>22.0</td>
<td>32.0</td>
</tr>
<tr>
<td>Wheat offal</td>
<td>9.00</td>
<td>9.00</td>
<td>9.00</td>
<td>9.00</td>
</tr>
<tr>
<td>Palm kernel meal</td>
<td>10.0</td>
<td>10.0</td>
<td>10.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>31.0</td>
<td>31.0</td>
<td>31.0</td>
<td>31.0</td>
</tr>
<tr>
<td>Local fish meal</td>
<td>3.10</td>
<td>3.10</td>
<td>3.10</td>
<td>3.10</td>
</tr>
<tr>
<td>Vit. Premix</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Limestone</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
</tr>
<tr>
<td>Lysine</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>Methionine</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>Salt</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Chemical compositions

<table>
<thead>
<tr>
<th>Crude protein (%)</th>
<th>22.0</th>
<th>21.7</th>
<th>21.5</th>
<th>21.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat (%)</td>
<td>2.98</td>
<td>2.41</td>
<td>2.34</td>
<td>1.93</td>
</tr>
<tr>
<td>Fiber (%)</td>
<td>2.75</td>
<td>2.92</td>
<td>3.06</td>
<td>3.21</td>
</tr>
<tr>
<td>Calcium (%)</td>
<td>1.04</td>
<td>1.13</td>
<td>1.21</td>
<td>1.28</td>
</tr>
<tr>
<td>Phosphorous (%)</td>
<td>0.49</td>
<td>0.56</td>
<td>0.66</td>
<td>0.74</td>
</tr>
<tr>
<td>Metabolizable/pou</td>
<td>2822</td>
<td>2794</td>
<td>2770</td>
<td>2747</td>
</tr>
<tr>
<td>ltry/Kcal</td>
<td>.11</td>
<td>.03</td>
<td>.63</td>
<td>.23</td>
</tr>
<tr>
<td>Cost/kg. feed(N)</td>
<td>233</td>
<td>209</td>
<td>189</td>
<td>167</td>
</tr>
<tr>
<td>Cost/25kg. feed</td>
<td>5827</td>
<td>5239</td>
<td>4749</td>
<td>4191</td>
</tr>
</tbody>
</table>

*Crude protein = N x 6.25., ME=Metabolizable energy, MEP=Metabolizable energy of production

Data Collection and Experimental Design

The groups feed intake was recorded at the interval of 7 days till the 8th week of the trial study and parameters measured. The initial live weight of the chicks was determined, by weighing them
individually at the commencement of the experiment and at the weekly interval till the end of the study. The economic benefit analysis was calculated based on the method of Anigbogu (1996), and Anigbogu (2003), where the cost of dietary ingredients (N/kg) was used to calculate the cost/kg of the diets.

Data collection for growth performance and economic benefits were calculated as described below:

- **Average daily weight gain** = \( \frac{\text{Final weight - Initial weight}}{\text{Total number of days}} \)
- **Average daily feed intake** = \( \frac{\text{Total feed intake}}{\text{Total number of days}} \)
- **Feed efficiency** = \( \frac{\text{Weight gain}}{\text{Feed intake}} \)
- **Efficiency of feed utilization** = \( \frac{\text{Weight gain}}{\text{Total feed intake}} \)
- **Feed Conversion Ratio** = \( \frac{\text{Total Body weight}}{\text{Cost/kg of feed} \times 10000} \)
- **Cost/kg of feed** = \( \frac{\text{Cost per kg of feed}}{100} \)
- **Cost of total feed intake** = \( \text{Total intake} \times \text{Cost per kg of feed} \)
- **Cost/kg weight gain** = \( \frac{\text{Cost per kg of feed} \times \text{Feed conversion ratio}}{\text{Cost/kg of feed}} \)
- **Cost of production** = \( \text{Cost of input} \times \text{Cost of chicks} \)
- **Gross profit** = \( \text{Price} \times \text{Final weight of life chicks} \)
- **Profit** = \( \text{Gross Profit} - \text{Cost of production} \)
- **Return on Investment** = \( \frac{\text{Profit} \times 100}{\text{Cost of investment}} \)

A Completely Randomized Design (CRD) with 4 treatments and 3 replicates were adopted for this experiment based on Gomez and Gomez (2005). There were 30 birds in each treatment, was replicated 3 times with 10 birds per replicate.

The statistical model used:

\[ Y_{ij} = \mu + T_i + e_{ij} \]

Where \( Y_{ij} \) = single observation  \\
\( \mu \) = mean overall  \\
\( T_i \) = effect of diet  \\
\( e_{ij} \) = the random error

The random error is independent, identically and normally distributed.

**Data Analysis**

All data gathered at the end of the study were analyzed using the Analysis of Variance (ANOVA) of Completely Randomized Design (CRD) as in Gomez and Gomez (2005). The mean separation of significant effects was done using Duncan’s New Multiple Range Test where significance occurred as described by Gomez and Gomez (2005).

**Results**

Growth performance are presented in Table 3. The results revealed that initial weight was the same (p>0.05) across treatment levels. Final weight, average weight was significantly (p<0.05) higher in chickens fed D3 and D4 diets respectively. Total feed intake was (p<0.05) among D3, D4 and D2 diets than that of the control. Average daily feed intake and feed efficiency were not significantly (p>0.05) different among diets. Feed conversion ratio and efficiency of feed utilization were significantly (p<0.05) better for chickens fed D3 and D4 diets, when compare with that of the control.

**Table 3. Growth performance of broiler birds fed yam tuber waste meal as part of formulated diets (g/bird).**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Diet 1</th>
<th>Diet 2</th>
<th>Diet 3</th>
<th>Diet 4</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial weight</td>
<td>43.00</td>
<td>43.00</td>
<td>43.00</td>
<td>43.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Final weight</td>
<td>2633.33</td>
<td>2200.00</td>
<td>2966.66</td>
<td>2833.33</td>
<td>91.67</td>
</tr>
<tr>
<td>Weight gain</td>
<td>2590.33</td>
<td>2157.00</td>
<td>2922.67</td>
<td>2833.33</td>
<td>91.54</td>
</tr>
<tr>
<td>Ave. daily weight gain</td>
<td>46.26</td>
<td>38.52</td>
<td>52.46</td>
<td>49.81</td>
<td>1.65</td>
</tr>
<tr>
<td>Total feed intake</td>
<td>5086.47</td>
<td>5247.70</td>
<td>5268.73</td>
<td>5262.40</td>
<td>23.98</td>
</tr>
<tr>
<td>Ave. daily feed intake</td>
<td>90.83</td>
<td>93.71</td>
<td>94.08</td>
<td>93.97</td>
<td>0.43</td>
</tr>
<tr>
<td>Feed conversion ratio</td>
<td>1.93</td>
<td>2.39</td>
<td>1.78</td>
<td>1.86</td>
<td>0.08</td>
</tr>
<tr>
<td>Feed efficiency</td>
<td>0.51</td>
<td>0.41</td>
<td>0.55</td>
<td>0.53</td>
<td>0.01</td>
</tr>
<tr>
<td>Efficiency of feed utilization</td>
<td>1.96</td>
<td>2.43</td>
<td>1.80</td>
<td>1.89</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Means in the rows with difference superscripts are Significant at p<0.05, SEM = Standard error of the mean.
Carcass analysis are presented in Table 4. The results revealed significant (p<0.05) differences across treatment levels. Live weight, dressed weight, and dressed percentage were significantly (p<0.05) higher in chickens fed D3 diets when compared with that of the control and other diets respectively. Economic benefits are presented in Table 5. The results showed the economic cost benefits were significantly (p<0.05) better for chickens fed D3 diets, when compared with that of the control and other diets respectively.

Discussion

Growth performance

The result of the weight gained, average weight gain, feed conversion ratio, and efficiency of feed utilization of the broiler birds fed Diets 3 and 4 were significantly (p<0.05) better than those fed the other Diets. While the average daily feed intake and feed efficiency values revealed were not significant (p>0.05) among treatments (Table 3). The poor growth parameters observed in T2-fed birds were as a result of the limited composition of effective Neutral Detergent Fiber (eNDF) in the 12% yam tuber waste meal fed birds as in Diet T2 which is not sufficient to help improve the metabolism of the treated diet, when compared to those fed Diets T3 and T4 at 22% and 32% yam tuber waste meal, respectively. The birds fed Diets T3 and T4 with higher levels of yam tuber waste meal received higher composition of eNDF which contributed to their good performances as against the Diet T2-fed birds with a lower level of yam tuber waste meal. This agrees with the observation of Anigbogu and Anigbogu (2001) who previously revealed that, eNDF in yam tuber aids in the metabolization of the resistant starches present in the tubers and other feed materials. The eNDF helps to stimulate the increase in digestive enzymes activities within the metabolic chamber of the animals. Kumar et al. (2013) proved that, yam tuber contributes in the metabolization of feed particles and aids in increasing the bacterial loads in the gut for better digestion and improvement in growth. Furthermore, Kumar et al. (2013); Padhan and Panda (2016) concluded that, the anti-oxidants and other phytonutrients present in the yam tubers are among the properties protecting farm animals against diseases, and help to increase the weight (weight gain, daily gain weight) and other production benefits.

It’s has been established that, the lower the feed conversion ratio the better the weight gain as noted by Anigbogu (2000/2001), Anigbogu and Madu-Ijeoma (2015) in similar studies, when tannia tuber meal was fed to broiler birds and life-enzyme fed to the goats, respectively. Hence, the lower feed
conversion ratio and better weight gain and other growth parameters as obtained in this study showed that, yam tuber waste meal could replace maize in broiler diets at 22% - 32% inclusion rates, without depression in weight gain and other growth parameters. This agreed with Atuahene et al. (2019), and Anigbogu (1996), who studied the feeding of yam tuber meal and taro tuber meal, respectively on broiler birds with similar results. While Anigbogu and Anigbogu (2001) revealed that, the eNDF present in the yam tuber helped in the metabolism of resistant starch, which stimulated the increase in digestive enzymes performance in the feeds. Kumar et al. (2013) noted that, yam tuber helped to metabolize the feed particles and increase the number of bacteria in the gut for efficient productivity. This result is associated with the anti-oxidants and phytochemical in the yam tubers, which showed that, yam tuber has properties to protect farm animals against health illnesses (Kumar et al., 2013; Padhan and Panda, 2016). Furthermore, yam tuber has the following nutrient load per 100g energy value 158cal, carbohydrate 37g, protein 2g, crude fibre 5g, vitamin C 18% of daily value (DV), vitamin B5 9% (DV), manganese 22% (DV), magnesium 6% (DV), potassium 19% (DV), thiamine 11% (DV), copper 23% (DV), and foliate 6% (DV), which helped in the growth performance of the broiler birds as in this study (Otegbayo et al., 2018; Polycarp et al., 2010).

**Carcass characteristics**

Table 4 showed the carcass analysis of broiler birds fed Diets containing yam tuber waste meal. The result of the live weight, dress weight and dress percentage revealed that, broiler birds fed with Diets 3 and 4 were significantly (p<0.05) better than those fed with the other Diets. As noted in this study, yam tuber waste meal did not have any adverse effects in all parameters on the broiler birds studied on the carcass characteristics, which is in agreement with the studies of Olajide (2012) and Anigbogu (1995) in similar studies using tario tuber meal. This finding is also in agreement with Anigbogu and Anigbogu (2001) who found that, the anti-nutritional factors in yam tuber is significant (p<0.05), which affected the low level of alkaloids (0.02mg/100kg) in yam tuber samples. The anti-nutritional factors present helped to activate the animals’ physiological hydrolytic and digestive enzymes, when the yam tuber meal was given as part of a formulated diets to the farm animals. Further, it attributed to better metabolism in the physiology of the birds, that resulted in improved carcass characteristics, cost benefit analysis, weight gain and other growth parameters as agreed by Agiana et al. (2004), and as revealed in this study. They further stated that, the nutrient density of yam is associated with a number of health factors such as the weight gain, carcass characteristics, anti-inflammatory factors, anti-microbial effect and improved digestive health, that contributed to the growth in poultry production.

**Economics of production**

The economic benefits in production such as cost/kg feed, cost of feed intake, cost/kg weight gain and cost of production of the broiler birds fed Diets containing yam tuber waste meal as part of formulated diets, were significant (p<0.05) across the treatment groups as shown in Table 5. While the gross profit, profit, and return on investment followed similar trends at (p<0.05). This is in agreements with Anigbogu (2003), and Anigbogu (1996), who fed goats and birds with yam tuber meal and taro tuber meal respectively in similar studies and noted better economic benefits of production. He revealed that, yam tuber is not only an excellent source of fibre, but is high in potassium and manganese, which are essential in supporting bone health, growth, metabolism, and other farm animal physiological advantages, contributing to better economic gains as found in this study, and as noted by Otegbayo et al. (2018), and Otegbayo et al., (2010) in similar studies. Anigbogu (2003) further stated that, yam tuber provides a decent amount of micro-nutrients such as copper and vitamin C; and that the element copper is vital for red blood production and iron absorption, while vitamin C is a strong anti-oxidant that boosts the immune system and helps give room for better growth and other farm animal husbandry factors in the farm animal nutritional system (Padham and Panda, 2016; Polycarp et al., 2012).

**Conclusions**

Based on the findings of this study, we conclude that; the inclusion of the yam tuber waste meal at 22% - 32% levels in broiler diets improved weight gain, feed intake, the efficiency of feed utilization, feed conversion ratio, feed efficiency and economics of production. In this study, yam tuber waste meal had no adverse effects on the carcass characteristics of the broiler birds when fed as part of formulated diets. Based on this study’s results, it is recommended that 22% - 32% of yam tuber waste meal can be included in broiler diets without deleterious effects in all the parameters (growth performance, cost-benefit and carcass quality) studied.
Acknowledgements
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References


Olajide, R. 2012. Growth performance, carcass, haematometabolites and serum metabolites of broilers as affected by contents of anti-nutritional factors in...


