American International Journal of Agricultural Studies
Vol. 4, No. 1; 2021
ISSN 2641-4155 E-ISSN 2641-418X
Published by American Center of Science and Education, USA

REPLACEMENT VALUE OF MAIZE WITH OTHER CEREALS ON PERFORMANCE AND COST BENEFIT OF BROILER CHICKENS

Dr. Olufemi Olubunmi Egbewande
Associate Professor
Department of Animal Production
Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria
E-mail: femi2015.ooe@gmail.com

Prof. (Mrs.) Iyabo Comfort Alemede
Professor
Department of Animal Production Technology
School of Agriculture and Agricultural Technology
Federal University of Technology, Minna, Niger State, Nigeria
E-mail: tee_baby2k6@yahoo.com

Mr. Maroof Mohammed Afolabi
Department of Animal Production
Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria
E-mail: mofabs@yahoo.com

ABSTRACT

The study investigated the effect of replacing maize with alternatives (white sorghum, red sorghum, grey millet and brown millet) on the growth performance and cost benefit of broiler chicken. A total of one hundred and fifty (150) day-old Aboica strain broiler chicks were purchased for this study and were randomly allotted to five dietary treatments. The five is caloric and is nitrogenous diets for both the starter and finisher phases were formulated with the test ingredients (yellow maize, white sorghum, red sorghum, grey millet and brown millet) as the main source of energy and were designated as T1, T2, T3, T4 and T5. Each treatment was further divided into three replicates with ten (10) birds per replicate. The parameters investigated were growth performance and economics of production. This study revealed no significant ($p>0.05$) differences in weight gain among all the treatment. Furthermore, it showed a significantly ($p>0.05$) lower cost of producing the four alternatives as compared to the control (maize) and higher gross profit. It was concluded that white sorghum, red sorghum, grey millet and brown millet can replace yellow maize without any adverse effect on the health status and general performance of broiler chickens.

Keywords: Cost Benefit, Millet, Performance, Sorghum.

INTRODUCTION

Poultry is one of the animals with the highest rate of production and growth Ezieshi et al. (2004). Oke et al. (2016) also noted that it is the quickest source of meat, as it matures very quickly compared to other livestock. Ukomu et al. (2018) added that poultry products are popular and well accepted in all cultural, social and religious functions. Poultry meat and egg, generally regarded as the animal source foods, are the best sources of high quality protein and micro-nutrients that are essential for normal development and good health (Anyaegbu et al., 2018). According to Taste Inc. (2019), chicken provides less calories, as well as low cholesterol and saturated fat than beef. As regards health status, white meat (from chicken) is more preferable for consumption to red meat (beef) as the later has been correlated with increased incidence of certain body challenges, including cancer and heart related ailments (McAnlis, 2019). Nosike et al. (2018) clarified that chicken is suitable for high blood pressure and coronary heart disease patients. However, Nigerian poultry industry has been witnessing series of problems, owing largely to high cost of feed ingredients, which has been a major problem militating against progress in poultry enterprises in Nigeria (Anyaegbu et al., 2018). According to Igboeli (2000), provision of feed alone accounts for up to 80 % of the total cost of production, enough to rob the farmer of his total profit worth. In view of this ugly development therefore, Ukomu et al. (2018) considers it imperative to intensify efforts in the search for cheaper, abundant and locally available alternatives. To this effect, Ndanusa (2016) stressed that for good result, such alternatives must be used to replace the major energy or protein sources with the highest rate of inclusion in the diet.

The major energy source used in poultry feed formulation is maize. It takes up to 60 % of the poultry diet (Oyawoye et al., 2017). Maize is also a major staple food for human population in developing countries such as Nigeria. Hence, there is high competition for maize as livestock feed ingredient and as food by humans, which has led to high cost of maize, thereby increasing the cost of animal feed production. It is this high cost of the commodity, coupled with stiff competition for its consumption between man and livestock that has necessitated its replacement with its alternatives in formulation of poultry feed. According to Yisa et al. (2017), the most common alternative cereal grains used in replacement of maize in livestock feed are sorghum and millet. These contain nutritive values that are closely related to those of maize. More so, their inclusion in animal ration has not been found to have significant negative impact on the growth and performance characteristics of chickens. Mohamed et al. (2015) had reported an experiment in which sorghum had been used to replace maize up to 45 % and appeared to be biologically better without any adverse effects on broiler production. This study therefore investigated the impact of these important alternatives (white and red sorghum, and grey and brown millet) on the performances and cost benefit of producing broiler chickens.

MATERIALS AND METHODS

Experimental Location

The experiment was conducted at the Poultry Unit of Niger State Agricultural and Mechanization Development Authority (NAMDA), Maitumbi-Shiroro Road, Minna, Niger State, between July and September, 2019. Minna is a metropolitan settlement situated in the Southern Guinea Savannnah Vegetation Belt of Central Nigeria. It is situated on Latitude 9^0 37′ and Longitude 6^0 33′ (Longman, 2003) and bordered by Latitude 9^0 33′ and 9^0 42′ to the North and Longitude 6^0 27′ and 6^0 35′ to the East (Googlearth, 2012).

Sources of Experimental Ingredients

The test ingredients (maize, sorghum and millet) and soyabean were purchased from Maitumbi and Gunu markets. Vaccines, antibiotics, lysine, methionine and premixes were purchased from Step-by-Step Shop along Kpakungu - Dutsen Kura road, opposite Minna Ultra-Modern Market, while other ingredients, including bone meal, fishmeal and limestone were purchased from Timzac Livestock Ventures at Gbeganu along Bida road.

Experimental Diets

Five experimental diets were formulated using each of the test ingredients (yellow maize, white sorghum, red sorghum, grey millet and brown millet), mixed with other ingredients which included soya bean meal (full soya), fishmeal, wheat offal, bone meal, limestone, salt, lysine, methionine and vitamin premix. They were thoroughly mixed. The diet containing maize, which was the control diet, was labeled T1. The diets containing white sorghum, red sorghum, grey millet and brown millet were labeled T2, T3, T4 and T5 respectively. Two categories of the diets were formulated: starter diet which contained 23 % CP and fed to the birds from 1st- 4th week (Table 1), and finisher diet which contained 20 % CP and provided from 5th- 8th week (Table 2).

Table 1. Gross composition of experimental starter diet

Ingredient (%)	Treatments				
	T1	T2	T3	T4	T5
Maize	49.9	-	-	-	-
White Sorghum	-	49.9	-	-	-
Red Sorghum	-	-	49.9	-	-
Grey Millet	-	-	-	49.9	-
Brown Millet		-	-	-	49.9
Soya Bean Meal	31.6	31.6	31.6	31.6	31.6
Fish Meal	4.0	4.0	4.0	4.0	4.0
Wheat Offal	10.0	10.0	10.0	10.0	10.0
Bone Meal	2.0	2.0	2.0	2.0	2.0
Limestone	0.7	0.7	0.7	0.7	0.7
Salt	0.5	0.5	0.5	0.5	0.5
*Premix	0.5	0.5	0.5	0.5	0.5
Lysine	0.5	0.5	0.5	0.5	0.5
Methionine	0.3	0.3	0.3	0.3	0.3
Total	**100**	**100**	**100**	**100**	**100**
Calculated value (%):					
Crude protein	22.14	21.64	21.64	22.64	22.64
Metabolizable energy (kcal/kg)	2764.65	2733.71	2733.71	2370.44	2370.44

* Agri-Mix: A – 12,000,000IU; Vitamin B_1 – 2,000mg; Vitamin B_6 – 3,500mg; Vitamin B_{12} – 20mg; Vitamin D_3 – 3,000,000IU; Vitamin E – 30,000mg; Vitamin K_3 – 2,500mg; Antioxidanrt – 125,000mg, Biotin – 80mg; Calpan – 10,000mg, Choline Chloride – 200,000mg; Cobalt – 250mg, Copper – 8,000mg, Folic acid – 1,000mg; Iodine – 1,200mg; Iron – 40,000mg; Manganese – 70,000mg; Niacin – 40,000mg; Selenium – 250mg; Zinc – 60,000mg.

T1 = Yellow Maize based diet, T2 = White Sorghum based diet T3 = Red Sorghum based diet, T4 = Grey Millet based diet, T5 = Brown Millet based diet

Table 2. Gross Composition of experimental finisher diet

Ingredients (%)	Treatments				
	T1	T2	T3	T4	T5
Yellow Maize	59.0	-	-	-	-
White Sorghum	-	59.0	-	-	-
Red Sorghum	-	-	59.0	-	-
Grey Millet	-	-	-	59.0	-
Brown Millet		-	-	-	59.0
Soya Bean Meal	22.0	22.0	22.0	22.0	22.0
Fish Meal	4.0	4.0	4.0	4.0	4.0
Wheat Offal	10.0	10.0	10.0	10.0	10.0
Bone Meal	2.0	2.0	2.0	2.0	2.0
Limestone	0.7	0.7	0.7	0.7	0.7
Salt	0.5	0.5	0.5	0.5	0.5
*Premix	0.5	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5	0.5
Lysine	0.5	0.5	0.5	0.5	0.5
Methionine	0.3	0.3	0.3	0.3	0.3
Total	**100**	**100**	**100**	**100**	**100**
Calculated values:					
CP (%)	20.0	20.0	20.0	20.0	20.0
Energy kcal/kg	3460.7	3496.5	3446.2	3400.6	3453.6

*Agri-Mix: A – 12,000,000IU; Vitamin B_1 – 2,000mg; Vitamin B_6 – 3,500mg; Vitamin B_{12} – 20mg; Vitamin D_3 – 3,000,000IU; Vitamin E – 30,000mg; Vitamin K_3 – 2,500mg; Antioxidanrt – 125,000mg, Biotin – 80mg; Calpan – 10,000mg, Choline Chloride – 200,000mg; Cobalt – 250mg, Copper – 8,000mg, Folic acid – 1,000mg; Iodine – 1,200mg; Iron – 40,000mg; Manganese – 70,000mg; Niacin – 40,000mg; Selenium – 250mg; Zinc – 60,000mg.

T1 = Yellow Maize based diet
T2 = White Sorghum based diet
T3 = Red Sorghum based diet
T4 = Grey Millet based diet
T5 = Brown Millet based diet

Experimental Birds and Management

Before the arrival of the chicks, the pen was thoroughly cleaned and disinfected. Although well ventilated, adjustable air-resistant nylons were used to cover all the sides to ensure warmth. The floor was also well insulated with a thick layer of wood shavings upon which were laid sheets of papers to prevent injury to their eyes and to guard against swallowing of wood shafts. On arrival, they were immediately taken into the pen, already adequately heated using charcoal, to provide warmth for brooding. They were immediately served water containing glucose as anti-stress. Feed and clean water were supplied without restriction (ad libitum). Vaccination routine was carried out as follows:

2nd week - Lasota 1st dose

3rd week	-	Gumboro
5th week	-	Lasota 2nd dose

Medication was also made available, through drinking water. Vitalyte® was frequently served to prevent stress and improve appetite. Virucine® and Pox Proline® were used for the control and treatment of fowl pox. Amprolium® was administered to prevent coccidiosis and Neo-Furaseryl Plus was given when scouring was noticed.

Fresh water was provided every morning after washing the drinkers. Prompt removal and replacement of wet litter ensured a dry pen at all time which, coupled with good ventilation, prevented accumulation of ammonia and foul odor in and around the house. Throughout the trial, proper hygiene in and around the house helped to keep disease outbreak at bay.

Data Collection

Feed Intake

The amount of feed intake was determined on a weekly basis. A pre-determined quantity of feed was always served. At the end of the week, the left-over weight was subtracted from the amount feed served.

Body Weight

The birds were weighed (initial weight) at the start of the trial and weekly interval throughout the experimental period. The weekly body weight for the treatment groups were obtained collectively and divided by the number of birds in the groups to obtain the mean weekly weight for the treatment.

Body Weight Gain

The body weight gain for each week was obtained by the differences between the body weight for the preceding week and body weight for the current week. Body weight gain at the starter phase was determined using KERRO weighing scale with model number BL-P1D/20001. At the finisher phase, Digital weighing indicator with model number XK3190-A12E was used.

Feed Conversion Ratio (FCR)

The feed conversion ratio was determined on a weekly basis by dividing the quantity of feed consumed by the weight gain of the birds in each replicate in grams, using the following expression as cited by Malik et al. (2010):

$$\text{Feed Conversion Ratio (FCR)} = \frac{Average\ daily\ feed\ intake\ (g)}{Average\ daily\ weight\ gain\ (g)}$$

Estimated Cost of Production

The costs of feeding one bird per treatment for 8 weeks were determined by:

- Multiplying the proportions of each ingredient in the diets with the total feed consumed to obtain the actual quantity (kg) of the ingredient consumed.
- Multiplying the price of each ingredient with the quantity (kg) of that ingredient for the different experimental diets.

Statistical Analysis

All the data obtained were subjected to one-way analysis of variance (ANOVA) using Statistical Analysis System (SAS, 2010) and significant means were separated using Duncan's Multiple Range Test (Duncan, 1955).

RESULTS

Growth performance of broilers fed diets containing test ingredients at the starter phase

Table 3 showed results on growth performance of broiler chicks placed on diets containing the test ingredients at the starter phase. The result shows that there were no significant (p>0.05) differences in initial body weight of the birds at the beginning of the experiment and at the final stage of the starter phase (4th week). Also, there were no significant (p>0.05) differences in the feed intake and feed conversion ratio among all the treatments. Consequently, there was no significant difference in the growth pattern of the birds at the starter phase. However, numerical differences in total weight gains among all the treatments indicated an improvement in growth of birds in Treatment 5 over those in Treatment 1. Birds in treatment 2 (T2) recorded the lowest (817.27g) weight gain. For feed intake, Treatment 5 was consistent for recording a higher numerical feed consumption value than Treatment 1. Treatment 3 has the least feed intake. The best (1.55) feed conversion ratio was recorded in birds fed treatments 1 and 5. There were no mortalities throughout the feeding period.

Table 3. Growth performance of broiler fed diets containing test ingredients at starter phase

Parameter	Treatment					SEM	p value
	T1	T2	T3	T4	T5		
Initial weight (g)	41.12	40.17	41.61	38.88	38.21	2.05	0.46
Final weight (g)	899.15	857.44	867.75	862.37	898.22	9.31	0.09
Total weight gain (g)	858.03	817.27	826.15	823.47	860.01	10.48	0.12
Total feed intake (g)	1326.60	1330.37	1305.37	1318.27	1334.40	23.15	0.08
Average daily weight gain (g)	30.64	29.18	29.50	29.41	30.71	0.37	0.06
Average daily feed intake (g)	47.38	47.51	46.62	47.08	47.66	0.83	0.15
Feed Conversion Ratio	1.55	1.63	1.58	1.60	1.55	0.31	0.25
Mortality (%)	0.00	0.00	0.00	0.00	0.00	0.01	0.00

^{abc} Means of the same row with different superscript were significantly (P<0.05) different

SEM = Standard Error of Mean
LSD = Least Significant Difference
NS = Not Significant

T1 = Yellow Maize based diet
T2 = White Sorghum based diet
T3 = Red Sorghum based diet
T4 = Grey Millet based diet
T5 = Brown Millet based diet

Growth Performance of Broilers fed Test Ingredients at the Finisher Phase

Table 4 showed the result of growth performance of the birds at the finisher phase (4 – 8 weeks). Similar to starter phase, there were no significant (p>0.05) differences across all the treatment values at the finisher phase. However, Treatment 2 appeared to show a little improvement in growth at the final phase above the record in the starter phase. This prompted it to rank relatively equal in total weight gain with Treatment 4, although both still record the lowest numerical values. Numerically, Treatment 5 still recorded the highest value in total weight gain. Like in the starter phase, it was higher than Treatment 1, which was subsequently higher than Treatments 2, 3 and 4. Daily feed intake across the treatments revealed progressive growth pattern of the birds. Birds in Treatment 2 consumed highest, with resultant improvement in their growth, though way below Treatment 3. Feed intake in Treatment 5 was higher than in Treatment 1, and so there was a resultant higher body weight. While the feed conversion ratio of Treatment 5 and Treatment 1 remained the same, it differed for Treatments 2, 3 and 4.

Table 4. Growth performance of broilers fed diets containing test ingredients at finisher phase

Parameters	**Treatment**					**SEM**	**p value**
	T1	**T2**	**T3**	**T4**	**T5**		
Initial Weight (g)	899.15	857.44	867.75	862.37	898.22	9.32	0.00
Final Weight (g)	2730.74	2586.93	2625.63	2592.09	2735.58	40.08	0.00
Total Weight Gain (g)	1831.59	1729.49	1757.88	1729.72	1837.36	32.65	0.62
Total Feed Intake (g)	4444.42	4503.59	4475.23	4383.35	4464.44	50.09	0.25
Av. Daily Weight Gain (g)	65.41	61.77	62.67	61.78	65.62	1.79	0.25
Av. Daily Feed Intake (g)	158.73	160.82	159.83	156.55	159.44	1.17	0.62
Feed Conversion Ratio (g)	2.43	2.60	2.55	2.53	2.43	0.06	0.58
Mortality (%)	3.33^{a}	0.00^{ab}	0.00^{ab}	3.33^{a}	3.33^{a}	0.20	0.00

^{abc} Means of the same row with different superscript were significantly ($P<0.05$) different

SEM = Standard Error of Mean
LSD = Least Significant Difference
NS = Not Significant

T1 = Yellow Maize based diet
T2 = White Sorghum based diet
T3 = Red Sorghum based diet
T4 = Grey Millet based diet
T5 = Brown Millet based diet

Cost Benefit of Broiler Chickens fed Diets Containing Test Ingredients

Table 5 showed the cost benefit of broiler chickens fed diets containing test ingredients. Cost of feed production per kilogram was significantly ($p<0.05$) highest in Treatment 1. Although all the remaining treatments did not vary significantly, it was observed that dietary treatment 2 had the cheapest cost of production. Total cost of investment also varied relative to the cost of feed per kilogram. In all, Treatment 1 attracted significantly ($p<0.05$) highest cost of investment. However, unlike in the case of cost of feed per kg, Treatment 5 had the lowest cost of total investment. Gross return did not vary significantly ($p>0.05$) across the treatment means. However, Treatment 5 had a higher return than Treatment 1, which in turn was higher than all other treatments. For the gross profit, Treatment 5 emerged significantly ($p<0.05$) highest. It is followed by Treatment 2 which was also significantly ($p<0.05$) higher than Treatment 3. Although Treatment 4 had a higher profit margin, it was not significantly ($p>0.05$) different from Treatment 2.

Table 5. Economics of production of broiler chickens fed diets containing test ingredients

Parameters	T1	T2	T3	T4	T5
Cost at day old (N)	230	230	230	230	230
Final Weight (kg)	2.73	2.59	2.63	2.59	2.74
Total feed Intake (kg)	5.77	5.93	5.79	5.70	5.79
Cost of feed/kg (N)	151.66	141.44	142.89	146.26	142.37
Total cost of feed intake (N)	875.08	838.74	827.33	833.68	824.32
Fixed Cost (N)	430	430	430	430	430
Total Investment (N)	1535.08	1498.74	1487.33	1493.68	1484.32
Cost of bird/kg (N)	800	800	800	800	800
Gross return (N)	2184	2072	2104	2072	2192
Gross profit (N)	648.92	573.26	616.67	578.32	707.68

Total Cost of Feed Intake = Cost of feed/kg x Total feed intake
Total Investment = Fixed cost + Total cost of feed intake + Cost at day old
Gross Return = Final weight x Cost of bird/kg
Gross Profit = Gross return – Total investment

DISCUSSION

Growth performance of broiler chickens fed diets containing test ingredients

The results showed no significant (P<0.05) differences in growth among the experimental diets at both starter and finisher phases. This compared well with the results obtained by Akinmoladun et al. (2015) when they fed broilers different energy sources using maize as the control. Adamu et al. (2006) also reported no significant side effect on growth when sorghum completely replaced maize in poultry diets. The result is also supported by Medegu et al. (2010) who reported no significant differences in the Dry Matter (DM) intake in chick fed sorghum and millet as replacement for maize.

The current study shows that initial weight, final weight, feed intake and feed conversion ratio of the birds did not differ (p<0.05) significantly for the various treatments at the two phases. Although this is in complete harmony with Medegu et al. (2010) who had reported similar results earlier, it is however noteworthy that Treatment 3 which contained red sorghum outperformed Treatment 2 which is white-sorghum based, in the two phases. This does not agreed with the findings of Selle et al. (2013) and Liu et al. (2015) which revealed that white sorghum-based diets had a better performance than chickens offered red sorghum-based diets. The result also contradicts the assertion of Freitas (2014) that white sorghum was easier for animals to digest than the red variety.

One probable cause for this incongruence may be that the red sorghum procured for this experiment was very low, or absent in, tannin content. If this is the case, then it will compare favorably with the report of Jacquie (2015) that there is now availability of tannin-free sorghum which tremendously improves its value in poultry diets. Also, according to Rooney et al. (2000), tannin-free red sorghum had higher total phenols than white sorghum.

Cost benefit of broiler chickens fed diets containing test ingredients

Economics of production analysis indicated that the highest cost per kilogram of feed belongs to the Control diet (Treatment 1) and the cheapest was Treatment 2, closely followed by Treatment 5. Treatment 5 recorded the highest profit margin. From the outset, it would appear that Treatment 1 had a profit margin higher than Treatments 2, 3 and 4. However, when the gross profit is compared with the total cost of investment in each treatment, it becomes obvious that all the studied alternatives performed better than the Control (Treatment 1) in terms of economic gain. The cost differentials in the study can be explained from two standpoints – current market prices of the test ingredients at the time of their purchase and their nutrient contents, particularly energy. A kilogram of yellow maize sold for N73.33 while grey and brown millets cost N66.67. White sorghum was the lowest in price at N53.33 per kilogram followed by red sorghum at N60 per kilogram. Consequently, white sorghum offered the lowest cost of production, but this advantage is overshadowed by brown millet which has a higher content of both crude protein and energy. Despite costing more than white sorghum and included at a level higher than all other test ingredients in their various dietary preparations, it considerably reduced the quantity of soya beans needed for balancing dietary treatment 5 (Tables 3.2 and 3.3). This led to the eventual drop in the cost per kilogram of Treatment 5 since soya bean meal, being a protein source in the diets, costs a whooping N180 per kilogram. The economic parameter obtained in this study compares favorably with the result obtained by Gebeyew et al. (2015) who reported in a similar study that sorghum was more profitable in replacement for maize in broiler diet. In a more incisive study, Yunusa et al. (2015) deduced that the two varieties of millet (Gero and Dauro) were a better substitute to maize in terms of performance and economic advantage.

CONCLUSION

From this study there was reduced cost of production when maize was replaced with sorghum and millet. The cereals were less expensive compared to maize and they were equally readily available. It is however safe to conclude that millet and sorghum can completely replace yellow maize in broiler diets without adverse effects. Nevertheless, birds fed brown millet (Gero) had the highest performance and best cost benefit and so, recommended as a replacement for maize in broiler diets. It is also recommended that further studies should be conducted on other poultry species such as layers and turkeys, to ascertain the suitability of these alternative energy sources. Government should intervene in form of grants and subsidies to farmers, to encourage large scale production of millet and sorghum.

REFERENCES

Adamu, M.S., Nafarnda, W.D., Iliya, D.S., & Kubkomawa, H.I. (2006). Replacing value of yellow sorghum (Sorghum bicolor) for maize in broiler diets. *Global Journal of Agricultural Science, 5*(2), 151-154.

Akinmoladun, O.F., Onibi, G.E., & Lamuwagun, A.T. (2015). Performance and economics of productions of broiler chicks fed diets of varying energy levels. Proceedings of 40th Conferences of Nigerian Society for Animal Production, 15th – 19th March, NAPRI/ABU Zaria. Pp. 399-402.

Anyaegbu, B.C., Okunkwo, D.N., Nosike, R.J., & Orji, M.C. (2018). Growth performance of starter broilers fed processed cocoyam (Xanthsoma sagittifolium) as energy source in place of maize. *Nigerian Journal of Animal Production, 44*(3), 230-237.

Duncan, D.B. (1955). Multiple range tests and multiple F-tests Biometrics, 11, 1-42

Ezieshi, E.V., Okhuenbie, I.F., Ezennabike, C.C., & Olomu, J.M. (2004). Comparative performances of broiler chicks fed graded levels of palm kernel oaks and maize offal. Proceedings of the 29th Annual Conference of Nigerian Society for Animal Production (NSAP). Pp. 253-256.

Frietas, E.R., Raquel, D.C., Nasciments A.J.N, Watanabe, P.H., & Lopes, I.R.V. (2014). Complete replacement of corn by white or red sorghum in Japanese quails feeds. *Brazilian Journal of Poultry Science, 16*(3), 333-336. http://dx.doi.org/10.1590/1516-635x1603333-336

Gebeyew, K., Mohamed, A., & Urge, M. (2015). The effect of replacing maize with sorghum on carcass characteristics and economics feasibility on commercial broiler chicken. Poultry, *Fish and Wildlife Science, 3*(1), 1-5.

Googlearth. (2013). Minna, Nigeria - A Satellite Image. Retrieved from www.googlearth.com

Igboeli, G. (2000). Animal production and Agriculture in the new millennium. *Nigeria Journal of Animal Production, 26*, 1-3.

Jacquie, J. (2015). Common feed ingredients in poultry diets. Retrieved from https://articles.extension.org/pages /68432

Liu, S.Y., Fox, G., Khoddami, A., Neilson, K.A., Truong, H.H., & Moss, A.F. (2015). Grain sorghum: a conundrum for chicken-meat production. *Agriculture, 5*(4), 1224-1251.

Malik, A.A., Balogun, O.O., & Dikko, A.H. (2010). An evaluation of the effect of storage of a locally produced and natural vitamin premise on the performance of layers hens. *Journals of Agriculture, Forestry and Social Sciences, 8*(1), 208-214.

McAnlis, C. (2019). White Meat Vs. Red Meat. Retrieved from https://www.fitday.com

Medegu, C.I., Kwari, I.D., Igwebuike J., Nkama I., & Mohammed I.D. (2010). Performance and economics of production of broiler chickens fed sorghum and millet as replacement for maize in the semi-arid zone of Nigeria. *Agriculture and Biology Journal of North America, 11*, 445-450.

Mohamed, A., Urge, M., & Gebeyew, K. (2015). Effects of replacing maize with sorghum on growth and feed efficiency of commercial broiler chicken. *Journal of Veterinary Science & Technology, 6*(3), 1-5.

Ndanusa, M. (2016). Effect of replacement of maize with soaked mango seed kernel meal on the growth performance and carcass characteristics of broiler chickens. An undergraduate thesis in the Department of Animal Production, Federal University of Technology, Minna, Niger State. P 3.

Nosike, R.J., Nwakpu, O.F., & Okocha, C.N. (2018). Phenotypic correlations between biological markers and growth traits in Arbor acres broiler chicken strain. *Nigerian Journal of Animal Productions, 45*(2), 21-28.

Oke, F.O., Oluwatosin, O.O., & Adeyemi, O.A. (2016). Performance Characteristics and Nutrient Digestibility of Finisher Turkeys Fed Diets Containing Malted Sorghum with Varying Combinations of Additives. *Nigerian Journal of Animal Production, 43*(1), 77.

Oyawoye, E.O., Joseph, D.S., & Okurerie, A.M. (2017). Replacement value of sundried cassava peel meal for maize in broiler ration. Proceedings on 42nd Annual Conference Nigerian Society for Animal Production. Pp. 434-437.

Rooney, L.W., & Waniska, R.D., (2000). Sorghum food and industrial utilization. In: Smith, C.W., Frederiksen, R.A. (Eds). Sorghum: Origin, History, Technology and Production. Wiley, New York. Pp. 689-729.

SAS. (2010). Statistical Analysis System SAS/STAT 9.2 user guide. SAS Institute Incorporation, Cary, North Carolina, USA.

Selle, P.H., Liu, S.Y., & Cowieson A.J. (2013). Steam-pelleting temperatures, grain variety, feed form and protease supplementation of mediumly ground sorghum-based broiler diets: Influences on growth performance, relative gizzard weights, nutrient utilization, starch and nitrogen digestibility. *Animal Production Science, 53*, 378-387.

Taste Inc. (2019). Battle of the Meats: Chicken Vs. Beef. Retrieved from https://www.tasteinc.com

Ukomu, E.C., Ohanaka, A.U.C., Uzegbu, H.O., & Oduehie D.N. (2018). Response of finisher broiler birds fed graded levels of yam peel meal as an energy source in maize-based diet. *Nigerian Journal of Animal Production, 45*(2), 185-188.

Yisa, G., Edache, J.A., Kamshiwe, B. Yaro, B., & Okwechime, A. (2017). Comparative effects of different cereal grains on growth performance of broiler starter chickens. 42nd Annual Conference of Nigerian Society for Animal Production. Pp. 457-459.

Yunusa, Y., Doma, U.D., Zahraddeen, D., Abubakar, S.B., Umar, A., & Isah, A. (2015). Performance and economics of production of broiler chickens fed different dietary energy sources. *Asian Journal of Poultry Science, 9*, 41-49.