



## Effect of Dietary Supplementation of DL – Methionine on the Performance and Cost Benefit of Broiler Chickens Fed Red Sorghum (*Sorghum Bicolor*)

<sup>1</sup>Olusiyi, J. A., <sup>2</sup>Doma, U. D., <sup>2</sup>Bello, K. M. and <sup>2</sup>Abubakar, M. K.

<sup>1</sup>Department of Animal Production and Health, Federal University, Wukari, Taraba State, Nigeria.

<sup>2</sup>Department of Animal Production, Faculty of Agriculture and Agricultural Technology, Abubakar Tafawa Balewa University, Bauchi, Nigeria.

### Abstract

Feeding trial lasting for eight weeks was carried out using a total of three hundred day old broiler chicks raised on deep litter to determine the growth performance and carcass characteristics of broiler chicks fed red sorghum diet supplemented with graded levels of methionine. They were fed five dietary treatments containing 0.1, 0.2, 0.3, 0.4 and 0.5% methionine representing T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub> and T<sub>5</sub> respectively. The birds were divided into three replicates of twenty birds per replicate; making a total of sixty birds per treatment. The study was conducted in a Completely Randomized Design (CRD), and birds were randomly assigned to five dietary treatments. The experiment was divided into two phases, 1 – 4 weeks (starter phase) and 5 – 8 weeks (finisher phase). All data generated were subjected to one way analysis of variance (ANOVA). Differences between means were compared using Duncan Multiple Range Test. The daily feed intake (DFI) were not significantly ( $P > 0.05$ ) different, while the daily weight gain (DWG) were not significantly ( $P > 0.05$ ) different also. However, feed conversion ratio (FCR) was significantly ( $P < 0.05$ ) different in the starter phase but not in the finisher. Feed cost per kg weight gain also increased across treatments. Therefore, diet 1 which had 0.1% methionine gave the least cost per kg gain of ₦449.94 and it is the best point of production. From the result, it can be observed that red sorghum can be supplemented with graded levels of synthetic methionine at up to 0.5% level without adverse effect on the productive performance as it neutralizes the tannic acid effect of red sorghum.

**Keyword:** Red Sorghum, Broiler chickens, and Synthetic methionine and cost benefit.

### Introduction

The tremendous increase in human population and high demand for animal feedstuff which causes rapid increase in cost of feed has led to the search for alternative cheap energy sources for livestock by farmers. This is as a result of the fact that feed cost is estimated to represent over 70% of the total cost of producing poultry intensively (Ogunfowora, 1984). Cereal grains especially maize has for long been used as conventional energy source in broiler production. This is simply because maize served as the standard against which other grains are compared (Atteh, 2002). Durunna *et al.* (2000) reported that maize is the major source of energy in poultry feed and constitute about 50% of poultry diets. Unfortunately, the rapid growth of human population has intensified the competition between man and livestock for

this cereal grain resulting in high cost of feeds and consequently high prices of poultry products, leading to very low levels of protein intake in most developing countries (Abdulrashid and Agwunobi, 2009). The ever escalating cost of maize as a result of increased competition for its usage by man, other livestock species and for industrial purposes (Egbunike and Achiobong, 2002), and its inadequate production to meet the needs of man and livestock (Babatunde *et al.*, 1990), has made it critical to look inward and consider other local varieties of cereals like red sorghum which is relatively cheap in their area of cultivation and can favourably compete with maize in broiler diets (Ibitobe *et al.*, 2012). One important measure that can be taken to alleviate this situation is the use of alternative energy source like red sorghum which is produced extensively in the semi-

arid zone area and also in less demand for other usage like maize.

Red sorghum is one of the most important feed and food crops in the arid and semi-arid tropics (Hill and Hanna, 1990). In the year 2010, Nigeria was the world's largest producer of sorghum followed by the United States and India (Mutegi et al., 2010). Red sorghum is comparable to maize in nutrient composition but contains some anti-nutritional factors which give it some agronomic advantages but lower the nutritional value of the grain for non-ruminants (Jacob et al., 1996). According to Aduku (2004), sorghum is lower in energy than maize, but it is higher and more variable in protein (8-12%) than maize. The author observed that more drought resistant than maize, but some varieties in Nigeria contain tannin in a range of 0.12 – 0.25%. Tannin has a deleterious effect on nutritive value of red sorghum as there is reduction in amino acid availability with increasing tannin content. Another disadvantage of tannin to non-ruminant is low protein digestibility (Gualtieri and Rapaccini, 1990). In general, low tannin sorghum are nearly equal to maize when fed to broiler chickens. However, the detrimental effects of high tannin in red sorghum on growing chicks may be alleviated by supplementing practical diets with lysine and methionine (Okoh et al., 1982), hence the supplementation of the experimental diets with graded levels of methionine. This study was therefore, aimed at assessing the dietary effects of supplementation of methionine on growth performance and cost benefit of broiler chickens fed red sorghum diets.

### Materials and Methods

**Study area / experimental site:** The study was carried out at the Poultry Units of Teaching and Practical Farm of Taraba State College of Agriculture, Jalingo. The state is in the North-East geo-political zone of Nigeria. It lies between latitude 8°52' 59 N and 11° 22'E North and longitudes 8.89° N and 11.38 E East of the equator in the Savannah zone of Northern Nigeria (TRSD, 2008). There are two main seasons existing in the area of study.

It has an annual rainfall of 1000 - 1500mm with temperature range of 30<sup>0</sup> - 42<sup>0</sup>. The state characterized by tropical climate marked by dry and rainy/wet season. The rainy season usually commence in the month of March and ends in October, while dry season start in later October and ends in March (TRSD, 2008).

### Experimental birds and their management

A total of three hundred (300) day-old Anak white broiler chicks of mixed sexes were used for the experiment. The chicks were raised/brooded on a deep litter management system for a period of one week. During the brooding, all the necessary management practices were strictly adhered to. After the brooding, the chicks were randomly allocated to various experimental treatments.

### Experimental diets and design

Five dietary treatments were formulated in which red sorghum was supplemented with graded levels of methionine at 0.1, 0.2, 0.3, 0.4 and 0.5% for T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub> and T<sub>5</sub>, respectively. Each dietary treatment is made up of sixty birds and three replicates of twenty (20) birds each and coded R<sub>1</sub>, R<sub>2</sub>, and R<sub>3</sub>. The experiment was conducted in a Completely Randomized Design (CRD) in a conventional poultry house. The feeding trial lasted eight (8) weeks in two phases i.e. 1-4 weeks (starter phase) and 5 – 8 weeks (finisher phase). Feed and clean water were provided *ad libitum*, while routine medication and management practices were strictly followed.

### Data Collection

**Performance data:** The performance parameters measured include daily feed intake (DFI), daily weight gain (DWG), and feed conversion ratio (FCR). DFI was measured by serving a weighed quantity of the experimental feed to birds in each replicate. After twenty four (24) hours, the amount of feed consumed per bird/replicate was then calculated for each treatment on daily basis. This was done by subtracting the quantity of leftover feed from the original feed given divided by the number of birds per

replicate. The birds were weighed at the beginning of the experiment so as to determine the initial weight and thereafter, on weekly basis to determine the weekly weight gain. The daily weight gain was obtained by

$$FCR = \frac{\text{Daily feed intake}}{\text{Daily weight gain}}$$

Mortality were recorded as they occur throughout the experimental period. Mortality rate was determined by dividing the number of dead birds by the total number of birds which was expressed as percentage mortality.

$$\text{Mortality} = \frac{\text{Number of dead birds}}{\text{Total number of birds}} \times \frac{100}{1}$$

Financial / Cost benefit of using red sorghum supplemented with methionine for broiler chicken production was determined according to Oyewole (2011).

### Proximate Analysis

The proximate composition of the experimental diets was determined according to the method of AOAC (2011).

### Statistical analysis

All data generated were statistically analysed using one way analysis of variance (ANOVA) as by Steel and Torrie (1980). Differences between treatment means were separated using Duncan's Multiple Range Test (DMRT) (Duncan, 1955).

### Results and Discussion

The ingredient composition of the experimental broiler starter and finisher diets were as presented in Tables 1 and 2. In the broiler starter diets (1-4 weeks red sorghum ranges between 46.57 – 47.10% and soya-bean ranged from 33.60 to 33.73%, while methionine was supplemented at the levels of 0.1, 0.2, 0.3, 0.4 and 0.5% for T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub> and T<sub>5</sub> respectively as shown in Table 1. Table 2 shows the composition of broiler finisher diet (5 – 8) weeks. Here, red sorghum has a range of 52.70 – 53.09%, while every other ingredient remains unchanged. Table 3 reveals the proximate composition of starter diet with crude protein range from 22.70 to 23.70%. These are close to the values 22.42% recommended by recommended by Olomu (1995) and also agree with the report of Alaku, (2010) who observed that young growing poultry requires more amount of protein than adults. Table 4 represents the

dividing the total weight gain of birds per replicate by the number of birds in the replicate and 7 days per week. On the other hand, FCR was calculated as the feed intake per unit weight gain. This was computed.

proximate composition (%) of the experimental broiler finisher diet. The crude protein (CP) ranges between 20.50 and 21.91%. It is slightly higher than 18.20% recommended by Olomu (1995) and 20% recommended by other workers (Firman, 1993 and Saskatchewan, 2000). It is in line with the assertion of Alaku (2010) that older birds require less CP than younger ones.

**Productive Performance:** Results of productive performance is shown in Table 5. Daily feed intake (DFI) was not significantly (P>0.05) different. This agrees with the report of Younis (2014) and Alfred (2014) who obtained similar report, when broiler chickens were fed toasted white sesame seed (*Sesamun indicus*) meal as methionine supplementation in broiler diets (DFI) values of 86.64 to 89.97g in the finisher phase are close to the range of 83.64 to 100.77g and 85 to 115g per day reported by Alfred (2014) and Wikivet (2012), respectively. The highest value was in T<sub>5</sub> (89.97g) while the least was in T<sub>1</sub> (86.64g). As can be observed, there is slight increase of DFI with increased levels of methionine inclusion. This agrees with the report of summer *et al.* (1992) who observed that the level and balance of essential amino acids (EAAs) also significantly affected feed intake and consequently weight gain and carcass composition. Results of DWG was significantly (P<0.05) in the starter phase but were not significant (P>0.05) affected in the finisher and overall phase. DWG also

increased slightly with increase levels of synthetic methionine from T<sub>1</sub> – T<sub>5</sub>. This also agrees with the reports of other workers (Younis, 2014 and Alfred, 2012). The highest value of DWG was in T<sub>5</sub> (63.58g) and the least in T<sub>1</sub> (60.89g). The result is in tandem with Meirelles *et al.* (2003), who reported that DL – methionine was effective in promoting a better live weight performance of birds when compared to methionine hydroxyl analogue, and higher methionine levels increased weight gain. Similarly Kim *et al.* (2006) reported that methionine could be added to overcome growth depression even when caused by dietary tannin acid and mild high tanmin toxicity, via the property of methyl donor. The inclusion of methionine and coarse crush/grinding of red sorghum diet suppressed the tannin acid effects on birds, hence the ability of the birds to overcome the deleterious effect of tannmins on productive performance. Result of feed conversion ratio (FCR) shows significant ( $P < 0.05$ ) difference in the starter phase but were not significantly ( $P > 0.05$ ) different in the final and overall phases. This is in agreement with findings of Ngele *et al.* (2011). The FCR range of 2.20 to 2.22 is lower than 5.07 to 6.50 reported by Akinusi (1999) and within 1.98 – 2.59 reported by Amaefule *et al.* (2005) and also within the range of 1.90 – 2.50 reported by Parkhust and Mountney (1997), who observed that feed conversion ratio in a well-managed broiler flock should be within that range or better depending on the nutrient density, time of year and other factors. However, Oluyemi and Roberts (2000) recommended feed conversion ratio of 2.10 – 5.10. The fact that this has a lower range of values is a proof to the efficacy and better utilization of the feed by the experimental birds. The mortality of 7% is higher than 5% reported by Oluyemi and Roberts (2000), who suggested that mortality rate should not exceed 5% to maximize profit and minimize unit cost of feed in production of broiler. The

highest mortality (9 birds) was recorded in T<sub>1</sub> followed by T<sub>3</sub> (5 birds) and the least in T<sub>5</sub> (1 bird). Invariably there was a decline in mortality with increasing levels of methionine inclusion. This is supported by the report of Bunchasak (2009) who observed that adding methionine to low protein diet reduced the mortality rate of hens under heat stress when compared to positive control group. This confirms the efficacy of methionine in boosting the immune system of birds. The cost benefits presented in Table 6, showed that feed cost (FC) was lowest in T<sub>1</sub> (₦227.24) /kg and highest in T<sub>5</sub> (₦ 235.6/kg. similarly total feed cost (TFC) was least in T<sub>1</sub> (₦ 902.14) and highest in T<sub>5</sub> (₦ 1,046). This can be attributed to increased level of methionine as observed Oguntoye *et al.* (2018). The least FC and TFC were obtained in T<sub>1</sub>.

### Conclusion

Base of the result obtained in this study, red sorghum can be supplemented with grade levels of synthetic methionine upto 0.50% without adverse effect on the productive performance as it neutralizes the tannic acid effect of red sorghum. The best performance and least cost per kg gain was in T<sub>1</sub> and is highly recommended for broilers production wherever it is highly available and cheaper than maize.

### References

- Abdulrashid, A. A. and Agwunobi, I. N. (2009). Taro cocoyam (*Colocasia esculenta*) meal as feed ingredient in poultry. *Pakistan Journal of Nutrition*. 8(5):668 – 673.
- Aduku, A. O. (2004). Animal Nutrition in the Tropics Feeds and Feeding Pasture Management, Monogastric and Ruminant Nutrition. Pp. 10.
- Akinusi, O. (1999). Utilization of Rice Milling Waste (RMR) in cockerel finisher ration. *Proceedes of 25<sup>th</sup> Annual NSAP Conference 21<sup>st</sup> – 25<sup>th</sup> March, Ilorin, Kwara State, Nigeria*. Pp 28-33

**Table 1: Ingredient Composition of Broiler starter Diets (1 - 4 Weeks)  
Containing Red sorghum Supplemented with varying Levels of methionine (%)**

Ingredients (%)	Level of methionine (%) in the diets				
	T1 (0.1%)	T2 (0.2%)	T3 (0.3%)	T4 (0.4%)	T5 (0.5%)
Red Sorghum	47.10	46.96	46.82	46.69	46.57
Soya bean	33.60	33.64	33.68	33.71	33.73
Wheat offal	9.00	9.00	9.00	9.00	9.00
Methionine	0.10	0.20	0.30	0.40	0.50
Fish Meal	5.00	5.00	5.00	5.00	5.00
Bone Meal	2.00	2.00	2.00	2.00	2.00
Lime Stone	1.50	1.50	1.50	1.50	1.50
Palm Oil	1.00	1.00	1.00	1.00	1.00
Salt	0.25	0.25	0.25	0.25	0.25
Premix*	0.25	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20	0.20
<b>Total</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>
<b>Calculated analysis</b>					
Crude Protein	23.47	23.47	23.47	23.47	23.47
ME (kcal/kg)	2934.88	2931.26	2928.12	2924.75	2921.41
Crude fibre (%)	3.49	3.49	3.49	3.49	3.49
Calcium (%)	1.62	1.62	1.62	1.62	1.62
Phosphorus (%)	0.80	0.72	0.72	0.71	0.72
Lysine (%)	1.33	1.33	1.33	1.33	1.33
Methionine (%)	0.52	0.52	0.52	0.52	0.52

\*Vitamin-mineral premix provided per kg; Vit. A 1500 IU; Vit.D<sub>3</sub> 3000 IU; Vit.E 30 IU; Vit.K 2.5mg; Thiamine B<sub>1</sub> 3mg; Riboflavin B<sub>2</sub> 6mg; Pyridoxine B<sub>6</sub> 4mg; Niacin 40 mg; Vit. B<sub>12</sub> 0.02mg; Pantothenic acid 10mg; Folic acid 1mg; Biotin 0.08mg; choline 0.125mg; Mn 0.0956g; Antioxidant 0.125g; Fe 0.024g; Cu 0.006g; 10.0014g; Se 0.24g; Co 0.240g

ME= Metabolizable energy

**Table 2: Ingredient Composition of Broiler finisher Diets (5 - 8 Weeks)  
Containing Red sorghum Supplemented with varying Levels of methionine (%)**

Ingredients (%)	Level of methionine (%) in the diets				
	T1 (0.1%)	T2 (0.2%)	T3 (0.3%)	T4 (0.4%)	T5 (0.5%)
Red Sorghum	53.09	52.97	52.82	52.70	52.56
Soya bean	22.61	22.63	22.68	22.70	22.74
Wheat offal	12.00	12.00	12.00	12.00	12.00
Methionine	0.10	0.20	0.30	0.40	0.50
Fish Meal	5.00	5.00	5.00	5.00	5.00
Palm Oil	3.00	3.00	3.00	3.00	3.00
Bone Meal	2.00	2.00	2.00	2.00	2.00
Lime Stone	1.50	1.50	1.50	1.50	1.50
Salt	0.25	0.25	0.25	0.25	0.25
Premix*	0.25	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20	0.20
<b>Total</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>
<b>Calculated Analysis</b>					
Crude Protein	20.53	20.53	20.53	20.53	20.53
ME (kcal/kg)	2989.12	2985.78	2982.38	2979.04	2975.66
Crude fibre (%)	3.05	3.05	3.05	3.05	3.05
Calcium (%)	1.62	1.62	1.62	1.62	1.62
Phosphorus (%)	0.78	0.76	0.76	0.76	0.76
Lysine (%)	1.09	1.09	1.09	1.09	1.09
Methionine (%)	0.51	0.51	0.51	0.51	0.51

\*Vitamin-mineral premix provided per kg; Vit. A 1500 IU; Vit.D<sub>3</sub> 3000 IU; Vit.E 30 IU; Vit. K 2.5mg; Thiamine B<sub>1</sub> 3mg; Riboflavin B<sub>2</sub> 6mg; Pyridoxine B<sub>6</sub> 4mg; Niacin 40 mg; Vit. B<sub>12</sub> 0.02mg; Pantothenic acid 10mg; Folic acid 1mg; Biotin 0.08mg; Choline 0.125mg; Mn 0.0956g; Antioxidant 0.125g; Fe 0.024g; Cu 0.006g; Zn 0.0014g; Se 0.24g; Co 0.240g

ME= Metabolizable energy

**Table 3: Proximate Composition (%) of Broiler starter Diets (1 - 4 Weeks) Containing Red sorghum Supplemented with varying Levels of methionine (%)**

Nutrients(%)	Level of methionine (%) in the diets				
	T1(0.1%)	T2(0.2%)	T3(0.3%)	T4(0.4%)	T5(0.5%)
Dry Matter	88.10	87.70	85.10	86.80	87.20
Moisture Content	11.90	12.30	14.90	13.20	12.80
Crude Protein	23.35	22.70	22.35	23.70	23.70
Crude Fibre	3.80	3.80	4.80	5.00	3.80
Ash	4.30	4.80	4.80	4.50	4.10
Ether Extract	8.06	7.68	9.13	8.00	7.87
NFE	48.59	49.72	45.02	45.60	47.73
ME (Kcal/kg)	3241.76	3190.04	190.04	3127.69	3143.70

NFE = Nitrogen Free Extract

ME = Metabolizable Energy

ME (kcal/kg) = 37 x % CP + 81 x % EE + 35.5 x % NFE (1985).

**Table 4: Proximate Composition of Broiler Finisher (5-8 Weeks) Diets Containing Red sorghum Supplemented with varying Levels of methionine (%)**

Nutrients(%)	Level of methionine (%) in the diets				
	T1(0.1%)	T2(0.2%)	T3(0.3%)	T4(0.4%)	T5(0.5%)
Dry Matter	87.90	87.90	88.40	88.70	88.00
Moisture Content	12.10	12.10	11.60	11.30	12.00
Crude Protein	20.50	20.50	21.90	20.85	21.05
Crude Fibre	4.60	4.20	6.00	5.60	4.60
Ash	4.40	4.70	4.40	4.20	4.70
Ether Extract	9.13	8.39	8.39	8.65	8.45
NFE	52.27	53.11	50.71	52.40	51.20
ME (Kcal/kg)	3241.62	3212.50	3179.10	3221.13	3206.90

NFE = Nitrogen Free Extract

ME = Metabolizable Energy

ME(kcal/kg) = 37 x % CP + 81 x % EE + 35.5 x % NFE (1985).

**Table 5: Performance of Broiler Chickens fed Red Sorghum Supplemented with Graded Levels of Synthetic Methionine (1 – 8 weeks)**

Parameters	Level of methionine (%) in the diets (%)					SEM
	T1 (0.1)	T2(0.2)	T3(0.3)	T4(0.4)	T5(0.)	
<b>Starter phase (1-4 weeks)</b>						
Initial weight (g)	92.10	93.17	92.83	94.00	93.17	1.00 <sup>NS</sup>
Weight gain (g/bird)	516.25	522.10	530.24	533.11	539.50	0.89*
Total Feed intake (g)	1539.40	1548.67	1574.40	1593.84	1645.50	0.97*
Daily feed intake (g)	54.98	55.31	56.22	56.92	58.77	0.89 <sup>NS</sup>
Daily weight gain(g)	18.44	18.65d	18.94	19.04	19.27	0.01*
Feed conv. ratio (FCR)	2.98	2.97	2.97	2.99	3.05	3.06*
Mortality (%)	1	0.33	0.67	0.67	-	
<b>Finisher Phase (5–8 Weeks)</b>						
Week 4 weight (g)	608.35	615.26	623.0	627.11	632.67	0.58 <sup>NS</sup>
Final weight (g)	1705.00	1721.60	1734.33	1759.00	1780.33	0.08 <sup>NS</sup>
Daily weight gain (g)	60.89	61.48	61.94	62.82	63.58	0.01 <sup>NS</sup>
Total Feed intake (g)	2425.87	2445.36	2469.75	2493.06	2519.20	5.60 <sup>NS</sup>
Daily feed intake (g)	86.64	87.33	88.21	89.04	89.97	0.07 <sup>NS</sup>
Feed conv. ratio	2.21	2.21	2.22	2.20	2.20	0.01 <sup>NS</sup>
Mortality (%)	2	0.67	1	0.33	0.33	-
<b>Overall (1 – 8 Weeks)</b>						
Initial weight (g)	92.10	93.33	92.83	94.00	93.17	11.61 <sup>NS</sup>
Final weight (g)	1705.00	1721.60	1734.33	1759.00	1780.33	58.94 <sup>NS</sup>
Total weight gain(g)	1612.90	1628.16	1641.50	1665.00	1687.16	25.12 <sup>NS</sup>
Daily feed intake(g)	70.81	71.32	72.22	72.98	74.37	1.35 <sup>NS</sup>
Total feed intake (g)	3965.36	3993.92	4044.32	4086.88	4164.72	5.40 <sup>NS</sup>
Daily weigh gain(g)	28.80	29.07	29.31	29.73	30.13	2.32 <sup>NS</sup>
Feed conv. ratio	2.46	2.45	2.46	2.45	2.47	0.05 <sup>NS</sup>
Mortality (%)	3	1	1.67	1	0.33	-

a,b,c = Means with different superscripts on the same row are significantly different = Significant (P<0.05)

NS = Not significant (P>0.05)

SEM = Standard Error of Means

**Table 6: Financial Benefits of Using Red Sorghum Supplemented with Methionine for Broiler Chickens Production**

Parameters	Level of methionine in the diets (%)				
	T1(0.1)	T2(0.2)	T3(0.3)	T4(0.4)	T5(0.5)
TFI (kg)	4.28	4.51	4.68	4.60	4.46
FC (N/kg)	227.24	229.02	230.28	233.01	235.61
TFC (N)	902.14	977.36	1,042.10	1,051.56	1,046.00
TWG (kg)	1.41	1.42	1.43	1.31	1.32
FC (N/kg gain)	449.94	453.46	455.95	466.02	501.85

TFI= Total feed intake

FC=Feed cost

TFC= Total feed cost

TWG= Total weight gain

Alaku, S.O. (2010). Introduction to Annual Science. JEE COMMUNICATION. Enugu, Nigeria Pp. 69 – 70.

Alfred, B. (2014). Effects of toasted white sesame seed (*Sesamum indicum*) meal as methionine supplementation in broiler diets in Guinea Savannah Zone of Adamawa State. A Master Thesis in Animal Production and Range Management of Modibbo Adama University of Technology, Yola, Nigeria.

Amaefule, K. U., Iheukwumere, F. and Nwaokoro, C. (2005). A note on the growth performance and carcass characteristics of rabbits fed graded dietary levels of boiled pigeon pea seed (*Cajanus cajan*). *Livestock Research for Rural Development* 17 (5): pp 142-145

A.O.A.C. 2011. Official Methods of Analysis (18<sup>th</sup> edition.) Assoc. Official Agric chemists. Washington. DC

Atteh, J. O. (2002). Principal and Practice of Livestock Feed Manufacturing. Adlek Printers, Ilorin, Nigeria, Pp. 13 – 17.

Babatunde, G. M., Pond, W. G. and Red, E. R. Junior (1990). Nutritive value of rubber seed (*Hevea brasiliensis*) meal. Utilization by growing pigs of semi purified diets in which rubber seed meal partially replaced soya bean meal. *Journal of Animal Science*. 68:392 – 397.

Bunchasak, C. (2009). Roles of dietary methionine in poultry production. Japan Poultry Science Association. 10. 2141/JPS9 46, 169. 382-385

Durunna, C. S., Udedibie, A. B. and Anyanwu, G. A. (2000). Combintion of maize/sorghum-based dried brewers grains. Cocoyam corn and cassava tuber meals as substitute for maize in the diets of laying hens. Proceeding of the 25<sup>th</sup> Annual Confarence Nigeria Society Amino Production, March 19 – 23, Umudike, Pp. 169 – 173.

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

Egbunike, G. N. and Achiobong, I. O. (2002). Performance and serum chemistry of growth: stimulated broiler finisher cassava peel base diet. Proceeding of the 7<sup>th</sup> Annual Conference of the Animal Science of Nigeria, September 16 – 19, Pp. 44 – 46.

Egbunike, G.N and Achiobong, I.O (2002). Performance and serum chemistry of growth: stimulated broiler finisher cassava peel base diet. Proceeding of the 7<sup>th</sup> Annual Conference of the Animal Science of Nigeria, September 16<sup>th</sup> – 19<sup>th</sup> Nigeria pp 44-46

Firman, J. D. (1993). Nutrient requirement of chicken and turkeys. Department of Animal Science, University of Mission, Extension.

Gualtieri, M. and Rapaccini, S. (1990). Sorghum grain in poultry feeding. *World's Poultry Science*. 46:246 – 254.

Hill, G. M. and Hanna, W. W. (1990). Nutritive characteristics of pearl millet grain in beef cattle diets. *Journal of Animal Science*. 68:2061 – 2066.

Ibitoye, E. B., Olerede, B. R., Jimoh, A. A. and Abubakar, H. (2012). Comparative performance and organ relative weight of broiler chickens fed three sources of energy diets. *Journal of Animal Production Advances*, 2(5):233 – 238.

Jacob, J. P., Mitaru, B. N., Mbugua, P. and Blair, R. (1996). The effect of substituting Kenyan serena sorghum for maize in broiler diets with different dietary crude protein and methionine levels. *Animal Feed Science Technology* 61:27 – 39.

Kim, W. K., Frochic, C. A. Jr., Patterson, P. H. and Rike, S. C. (2006). The potential to reduce poultry nitrogen emission with dietary methionine or methionine analogues supplementation. *World's Poultry Science Journal* 62: 271 – 276.

Mereilles, H. T., Albuquerque, R. Borgatti, L. M. O., Souza, L. W. O., Meister, N. C. and Lima, F. R. (2003). Performance of broilers fed with different levels of methionine hydroxyl analogue and DL – methionine. *World's Poultry Science Journal* 62:342-348

Mutegi, E; Sagnard, F., Muraya, M., Kanyenji, B; Rono, B. and Mwongera, C. (2010). Eco-geographical distribution of wild, weedy and cultivated sorghum bicolor (L) Moench in Kenya: Implications of Consumers. *Animal Feed Science Technology* 61:48-53.

Ngele, G. T; Oyawoye, E. O. and Doma, U. D. (2011). Performance of chickens fed raw and toasted sesame seed (*Sesamun indicum*) as a source of methionine. *Continental Journal of Agricultural Science* 5:33 – 38.

Ogunfowora, O. (1984). Structure, costs and notions in feedmill, Production Feedmill Management Training Workshop, April, 10 – May 2. Department of Agricultural Economics, University of Ibadan, Nigeria.

Oguntoye, M. A., Akintunde, A. R., Mafindi, U. M., Adamu, F. and Daniel, B. (2018). Effect of dietary supplementation of DL – methionine and sodium sulphate on growth performance, carcass characteristics and cost benefit analysis of broiler

- chickens fed maize – cassava based diets. *Journal of Animal Production Research*. 30(1):212 – 226.
- Okoh, P. N., Obilana, A. T., Njoku, P. C. and Aduku, A. O. (1982). Proximate analysis, amino acid composition and tannin content of improved Nigeria sorghum varieties and their potential in poultry feed. *Animal Feed Science Technology* 7:359 – 364.
- Olomu, J. M. (1995). Monogastric Animal Nutrition, Principles and Practice. Jackson Publication. University of Beni Nigeria Pp. 67 – 76, 320.
- Oluyemi, J. M. and Roberts, F. A. (2000). Poultry Production in Warm Wet Climates. Spectrum Books Limited, Nigeria, Pp. 224.
- Oyewole, B. O. (2011). Nutritional Potential of graded levels of fermented sweet orange (*Citrus sinensis*) fruit peel meal in the diets of pullet chicks, grower and layers. Ph.D Thesis. University of Agriculture, Makurdi, Nigeria. pp 205-209.
- Parkhurst, C. R. and Mounteney, G. J. (1997). Poultry meat and egg production CBS publishers and distributions, New Delhi, India, Pp. 110 – 190.
- Pauzenga, U. (1985). Feeding parret stock. *Journal of zootechnica international* 6:22-24
- Saskatchewan, A. (2000). Agriculture, Food and Rural Revitalization, 3085, Albert Street, Regina, Saskatchewan, Canada. 545 OBJ.
- Steel, R. G. and Torrie, J. A. (1980). Principles and Procedures of Statistics. A Biometrical Approach 2<sup>nd</sup> Ed. McGraw-Hill, Kogakusha Ltd. Tokyo.
- Summers, J. D; Sprath, D. and Atkison, J. L. (1992). Supplementation of a low protein diet in an attempt to optimize egg mass output. *Canadian Journal of Animals Science* 71:211 – 220.
- Taraba State Diary (TRSD, 2008). Taraba State Annual Official Diary. Taraba Printing press
- Younis, D. T. (2014). Effect of sorghum and methionine supplementation in productive performance and the quality of hatching eggs of two quail strains. *The Iraqi Journal of Veterinary Medicine* 38(2):22 – 27.
- Wikivet (2012). Chicken haematology <http://en.wikivet.net/chickens>. Retrved.