ISSN 0189-0514
J. Anim. Prod. Res. (2018) 30(1):212-226

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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

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ABSTRACT

Eight weeks (56 days) feeding trial was carried out using a total of two hundred and seventy (270), day-old broiler chicks to assess the growth performance, carcass characteristics and cost benefit analysis of broiler chickens fed maize-cassava based diets supplemented with DL-methionine and sodium sulphate. Nine experimental diets were laid out in a 3 × 3 factorial arrangement with three dietary inclusion levels of DL-methionine (0, 125 and 250 mg/kg) and sodium sulphate (0, 125 and 250 mg/kg). The experiment lasted for 0-28 days (starter phase) and 28-56 days (finisher phase). The birds were divided into nine treatment groups of 30 birds each. Each group was replicated three times in a completely randomized design of 10 birds per replicate. Data were analyzed using analysis of variance while means were compared using Duncan's New Multiple Range Test (DNMRT). The result of growth performance revealed that final weight, total weight gain and Average daily gain (ADG) showed significant ($P<0.05$) influence with dietary supplementation of DL-methionine and sodium sulphate at both starter and finisher phases. Birds fed diet supplemented with 250 mg/kg DL-methionine and 125 mg/kg sodium sulphate showed highest ($P<0.05$) values of 2045.01 g and 57.29 g for final weight and ADG at finisher phase. No significant effect of supplementation was observed on mortality. Highest percentage mortality of 4.44% observed in this study fall within the normal range. Birds fed diet containing 250 mg/Kg DL-methionine with 125 mg/kg sodium sulphate showed significantly higher revenue of ₦312.35/bird and benefit of ₦36.58/bird. Higher statistical values of 18.72%, 13.90%, 10.84% and 3.81% were recorded for breast, back, drumstick and gizzard respectively in the birds fed diet supplemented with 250 mg/kg DL-methionine + 125 mg/kg sodium sulphate interaction. It can be concluded that supplementation at level of 250 mg/kg DL-methionine with 125 mg/kg sodium sulphate reflected high significant values for growth performance and carcass yield without any deleterious effect on broiler chickens.

Key words: Maize-cassava, DL-methionine, sodium sulphate, broiler chickens.

INTRODUCTION

The astronomic increase in prices of feed ingredients such as maize is progressively slashing off the expected profit margin of livestock farmers in Nigeria and other developing countries across the globe. Poultry industry has not been able to fulfill the protein demand and supply challenges due to high cost of poultry feed ingredients, especially energy sources such as maize, wheat, barley and oat. Ekenyem and Madubuike (2006) observed that poultry products (meat and egg) offer considerable potential for bridging the gap of animal protein.

Monogastrics are the most efficient in converting protein feedstuffs and their by-products into high quality protein, compared to other livestock species (Mukhtar, 2007). In Nigeria, animal protein products have been in short supply due to

the ever increasing cost of livestock feedstuffs. However, the high cost of poultry feedstuffs especially protein feedstuffs has caused many feed manufacturers to derail by producing feed of poor quality which make farmers to produce below expectation and capacity (Nza *et al*., 2007). Obih (2009) suggested that greater emphasis should be placed on the use of unorthodox feed ingredients which are abundant, cheap and not competitive for human consumption. Cassava (*Manihot spp*.) is a common tropical root and tuber crop (FAO, 1996). It is extensively grown in Nigeria where it serves as a major source of food for both man and animals. Nigeria is the world's leading producer of cassava, producing up to 33 million metric tonnes per year (Ikwelle, 1999). It therefore represents a great potential in the country as an alternative source of energy for the feeding of both ruminant and monogastric animals. Utilization of whole unpeeled root is a total utilization concept; a strategy that is worth adopting in cassava utilization (Tewe and Bokanga, 2005). However, one serious setback in the use of cassava root meal is linamarin which on hydrolysis produces hydrogen cyanide (HCN) which is highly toxic (Hill,1977) with adverse effect on growth and physiological performance (Tewe and Bokanga 2005). 25% inclusion with palm oil supplementation was reported by Ojewola *et al.* (1999) to produce improved growth response. Cassava based rations need to be balanced for some nutrients and in particular sulphur containing amino acids, phosphorus, zinc, iodine and vitamin B_{12} (Hutagalung, 1977). Inorganic sulphur donor and amino acid such as methionine are crucial for improving bio-availability of nutrient such as protein through synergetic interactive influence particularly in ingredient of low nitrogenous content like cassava.

This study therefore, aimed at assessing the 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.

MATERIALS AND METHODS

Experimental birds design and management

A total of two hundred and seventy (270), day-old broiler chicks were purchased from a commercial hatchery. The birds were randomly divided into nine treatment groups of 30 birds each. Each group was replicated three times in a completely randomized design of 10 birds per replicate. The birds were raised in a deep litter housing system for 0-28 days (starter phase) and 28-56 days (finisher phase). Feed and clean water were provided *ad libitum* while routine medication and management practices were strictly followed.

Experimental diets

Nine isocaloric and isonitrogenous diets were laid out in a 3 × 3 factorial arrangement with three dietary inclusion levels of DL-methionine (0, 125 and 250 mg/kg) and sodium sulphate (0, 125 and 250 mg/kg). The diets were formulated for starter phase (0-4 weeks) and finisher phase (5-8 weeks) respectively as presented in Table 1 and 2.

Data collection

Growth performance

Average daily feed intake was obtained by subtracting the quantity of feed left-over from quantity of feed supplied to the birds per day. Weekly body weight gain was measured by subtracting the body weight of the bird in the preceding week from body weight of the following week. Feed conversion ratio (FCR) was obtained by dividing the average feed intake per bird per week by the weight gain per bird per week.

Cost-Benefit analysis of feed

The following parameters were determined using the procedure of Medugu *et al.* (2010)

- $Cost\ of\ feed\ per\ kg\ (₦) = \frac{summation\ of\ ingredients \times Cost\ per\ kg\ ingredient}{100}$
- Cost of feed consumed per bird (₦) = Cost per kg of feed × total feed intake per bird (kg)
- $Feed\ cost\ (\%) = \frac{Cost\ of\ feed\ consumed}{Cost\ of\ production} \times \frac{100}{1}$

- Cost of production = Operational cost + Cost of feed consumed
- Revenue generated per bird = Weight of the bird × Price/kg live weight
- Profit = Revenue - Total cost.

Carcass characteristics

At the end of the 8 weeks of feeding trial, one bird per replicate was randomly selected. The birds were deprived of feed for twelve hours before slaughter. The birds were allowed to bleed thoroughly before being scalded in warm water for de-feathering. They were eviscerated and organs and cut parts removed, weighed and calculated as percentage of live weight.

Statistical Analysis

Data collected were subjected to analysis of variance using the SPSS software (2012). Where analysis of variance indicated significant treatment effects, means were compared using Duncan's New Multiple Range Test (DNMRT) (SPSS, 2012)

RESULTS AND DISCUSSION

The results of main effects of varying levels of DL-methionine and sodium sulphate on performance characteristics of broiler chickens are presented in Table 3. Final weight, total weight gain, daily weight gain and feed conversion ratio were the growth indicators significantly ($P<0.05$) influenced by DL-methionine supplementation at starter phase. Final weight, total weight gain, and daily weight gain significantly ($P<0.05$) increased with increasing level of DL-methionine. Birds fed diet supplemented with 250 mg/kg DL-methionine recorded high significant value of 440.41g and 403.79g for final weight and weight gain. Improved weight gain with increasing level of methionine was reported by Garlick (1985). Also, Meirelles *et al.* (2003) reported improved weight gain with high level of DL-methionine. This study agrees with findings of Chattopadhyay *et al.* (2006) who reported improved dressing percent, thigh and breast yield in broilers with DL-methionine supplementation at the rate of 15g/kg. Sodium sulphate supplementation showed significant ($P<0.05$) effect on final weight, total weight gain, daily weight gain and feed conversion ratio. Birds fed with diet supplemented with 125 mg/kg sodium sulphate obtained higher values of 435.89 g, 397.12 g and 14.18 g for final weight, total weight gain and daily weight gain respectively. Statistical significant ($P<0.05$) values were obtained for feed conversion ratio across dietary treatments with birds on diet supplemented with 125 mg/kg sodium sulphate recording the least value of 2.85. The improved performance observed with sodium sulphate supplementation could be associated with increased water consumption and efficient nutrient utilization due to extra Na and decrease in pH due to sulphate anion as reported by Ruiz-Feria *et al.* (2011). Previous literatures (Morgin, 1980; Leeson and Summer, 2001) substantiate the aforementioned in which sodium (Na^+) was reported to be the principal cation of extracellular fluid involved in absorption of glucose and amino acid. It was observed that there was no significant effect of supplementation on mortality. Highest percentage mortality of 4.44 as observed in the current study fell within the normal range. N.C.C (2006) reported 5% as average mortality for broiler chickens.

The main effects of varying levels of DL-methionine and sodium sulphate on performance characteristics of finisher broiler chickens followed similar trend with starter phase. Final weight, total weight gain and daily weight gain showed significant ($P<0.05$) influence with dietary supplementation of DL-methionine. Values obtained for final weight significantly ($P<0.05$) increased with increasing level of DL-methionine, the same trend was observed for total weight gain and daily weight gain. Lowest value of 2.79 was obtained for FCR in the birds fed diet containing 250 mg/kg DL-methionine.

Sodium sulphate supplementation showed significant ($P<0.05$) influence on final weight, total weight gain and daily weight gain. Final weight, total weight gain and daily weight gain followed the same trend across dietary level of sodium sulphate supplementation with birds fed

diet containing 125 mg/kg sodium sulphate recorded higher significant ($P<0.05$) values. The improvements observed at the finisher phase could be associated with advanced digestive tract of the finisher birds which enhanced better nutrient digestion and utilization. The older the birds the better the ability to utilize nutrients (Fafiolu 2000).

Table 1: Gross Composition of maize-cassava based diet supplemented with varying levels of DL-methionine and sodium sulphate for starter broiler chickens

DL-methionine levels (mg/kg)	**0**			**125**			**250**		
Sodium sulphate levels (mg/kg)	**0**	**125**	**250**	**0**	**125**	**250**	**0**	**125**	**250**
Ingredients:	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**
Maize	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
PCRM	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Wheat offal	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Soy meal	12.80	12.80	12.80	12.80	12.80	12.80	12.80	12.80	12.80
GNC	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00
Fish meal (72%CP)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Oyster shell	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Lysine	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt (NaCl)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Supplements:									
DL-Methionine	-	-	-	125	125	125	250	250	250
Na_2SO_4	-	125	250	-	125	250	-	125	250
Determined analysis (%)									
Crude protein	23.01	23.01	23.01	23.01	23.01	23.01	23.01	23.01	23.01
Crude fibre	6.51	6.51	6.51	6.51	6.51	6.51	6.51	6.51	6.51
Ether extract	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61	4.61
Methionine**	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Lysine**	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
S**	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Ca**	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
P**	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
ME kcal/kg	2860.03	2860.03	2860.03	2860.03	2860.03	2860.03	2860.03	2860.03	2860.03

*Premix to supply per kg diet; 9,000,000IU of Vit A; 2,135,000IU of Vit D3; 20,000mg of Vit E; 1,340mg of Vit B1; 5,340mg of Vit B2; 1,670mg of Vit K3; 12,000mg of Pantothenate; 2,670mg of Vit B6; 13.4mg of Vit B12; 30,000mg of Niacin; 100mg of Biotin; 100mg of Folic acid; 63,340mg of Iron; 78,000 of Zinc; 1,17340mg of Manganese; 775mg of Iodine; 180mg of Selenium and 10,000mg of antioxidant; Na_2SO_4 = sodium sulphate ** = Calculated Value PCRM = Peeled Cassava Root Meal

Table 2: Gross Composition of maize-cassava based diet supplemented with varying levels of DL-methionine and sodium sulphate for finisher broiler chickens

DL-methionine levels (mg/kg)	**0.00**			**125**			**250**		
Sodium sulphate levels (mg/kg)	**0**	**125**	**250**	**0**	**125**	**250**	**0**	**125**	**250**
Ingredients:	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**
Maize	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
PCRM	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Wheat offal	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50
Soy meal	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
Palm oil	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30
GNC	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00
Fish meal (72%CP)	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Oyster shell	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Lysine	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt (NaCl)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Supplements:									
DL-Methionine	-	-	-	125	125	125	250	250	250
Na_2SO_4	-	125	250	-	125	250	-	125	250
Determined analysis (%)									
Crude protein	18.38	18.38	18.38	18.38	18.38	18.38	18.38	18.38	18.38
Crude fibre	7.63	7.63	7.63	7.63	7.63	7.63	7.63	7.63	7.63
Ether extract	4.82	4.82	4.82	4.82	4.82	4.82	4.82	4.82	4.82
Methionine*	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
Lysine**	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
S**	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Ca**	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74
P**	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
ME kcal/kg	2894.51	2894.51	2894.51	2894.51	2894.51	2894.51	2894.51	2894.51	2894.51

*Premix to supply per kg diet; 9,000,000IU of Vit A; 2,135,000IU of Vit D3; 20,000mg of Vit E; 1,340mg of Vit B1; 5,340mg of Vit B2; 1,670mg of Vit K3; 12,000mg of Pantothenate; 2,670mg of Vit B6; 13.4mg of Vit B12; 30,000mg of Niacin; 100mg of Biotin; 100mg of Folic acid; 63,340mg of Iron; 78,000 of Zinc; 1,17340mg of Manganese; 775mg of Iodine; 180mg of Selenium and 10,000mg of antioxidant . Na_2SO_4 = sodium sulphate ** = Calculated Value PCRM = Peeled Cassava Root Meal

The result of interaction effect of varying levels of DL-methionine and sodium sulphate on performance characteristics of broiler chicken is presented in Table 4. The result revealed that final weight, total weight gain and daily weight gain were significantly (P<0.05) influenced by interaction between DL-methionine and sodium sulphate at starter phase. Final weight and total weight gain increased significantly (P<0.05) with increasing level of DL-methionine across dietary levels of sodium sulphate. Birds fed with diet supplemented with 250 mg/kg DL-methionine and 125 mg/kg sodium sulphate (D8) revealed highest significant (P<0.05) values of 464.79 g, 425.94 g and 15.21 g/b/d for final weight, total weight gain and daily weight gain respectively. Feed intake, feed conversion ratio and mortality were not significantly (P>0.05) affected by dietary treatments.

The interaction effects of varying levels of DL-methionine and sodium sulphate on performance characteristics of finisher broiler chickens followed similar trend as with starter phase. Final weight, total weight gain and daily weight gain showed significant (P<0.05) influence with dietary supplementation of DL-methionine and sodium sulphate. Birds fed diet supplemented with 250 mg/kg DL-methionine and 125 mg/kg sodium sulphate showed highest (P<0.05) values of 2045.01 g and 57.29 g for final weight and daily weight gain. Fibre is known to hinder absorption of other nutrient as reported by McDonald *et al.* (1995) and level of variation would depend on individual bird's level of gizzard development to digest fibre. Improved growth performance could be associated with the increase in water intake due to extra Na ion and decrease in pH due to sulphate anion. Sulphate as a reducing agent has the capacity to induce oxidative reductive depolymerisation of starch polysaccharide (Paterson *et al.*, 1997). This attribute of sulphate, coupled with ability of methionine in reducing long chain fatty acid could be responsible for the improved synergetic interaction effect on the growth response. Dietary treatment showed no significant (P>0.05) influence on feed intake, FCR and mortality. This could be attributed to adequacy of the diet and being of no detrimental effect on the health status of the birds.

Table 3: Main effects of varying levels of DL-methionine and sodium sulphate on growth performance of broiler chickens.

	DL-methionine levels					Sodium sulphate levels				
Parameters	**0**	**125**	**250**	**SEM**	**p-value**	**0**	**125**	**250**	**SEM**	**p-value**
Starter (0-4 weeks)										
Initial weight (g)	38.75	38.90	38.84	0.22	0.210	38.84	38.77	38.88	0.22	0.150
Final weight (g)	418.96^{b}	421.92^{b}	440.41^{a}	1.05	0.013	422.12^{b}	435.89^{a}	423.29^{b}	1.05	0.001
Total weight gain (g)	380.21^{b}	383.02^{b}	403.79^{a}	1.88	0.016	383.26^{b}	397.12^{a}	386.63^{b}	1.88	0.000
Weight gain (g/b/d)	13.58^{b}	13.68^{b}	14.42^{a}	0.07	0.001	13.69^{b}	14.18^{a}	13.81^{b}	0.07	0.000
Feed intake (g/b/d)	40.03	40.41	40.06	0.23	0.320	40.10	40.37	40.04	0.23	0.180
Feed conversion ratio	2.95^{a}	2.95^{a}	2.78^{b}	0.02	0.000	2.93^{a}	2.85^{b}	2.90^{ab}	0.02	0.001
Mortality (%)	4.07	4.07	3.33	0.37	0.081	4.44	3.70	3.33	0.37	0.061
Finisher (5-8 weeks)										
Initial weight (g)	441.13	441.61	440.92	0.35	0.082	441.28	441.17	441.21	0.35	0.080
Final weight (g)	1873.59^{c}	1952.56^{b}	1994.46^{a}	10.73	0.015	1916.63^{b}	1959.02^{a}	1944.96^{ab}	10.73	0.001
Total weight gain (g)	1432.46^{c}	1510.95^{b}	1547.99^{a}	11.84	0.037	1475.35^{b}	1517.85^{a}	1498.19^{ab}	11.84	0.016
Weight gain (g/b/d)	51.16^{c}	53.96^{b}	55.29^{a}	0.38	0.000	52.69^{b}	54.21^{a}	53.51^{ab}	0.38	0.001
Feed intake (g/b/d)	149.01	149.88	150.38	0.31	0.000	149.29	150.23	149.75	0.31	0.091
Feed conversion ratio	2.91	2.78	2.72	0.02	0.000	2.83	2.77	2.80	0.01	0.000
Mortality (%)	2.59	2.63	1.85	0.63	0.091	3.33	1.89	1.85	0.63	0.082

^{ab}Mean values in the same row having different superscripts are significantly different (P<0.05)

Table 4: Interaction effect of varying levels of DL-methionine and sodium sulphate on growth performance of broiler chickens.

DL-methionine (mg/kg)	**0.00**			**125**			**250**				
Sodium sulphate (mg/kg)	**0**	**125**	**250**	**0**	**125**	**250**	**0**	**125**	**250**	**SEM**	**p-value**
Parameters											
Starter (0-4 weeks)											
Initial weight (g)	38.92	38.56	38.76	38.71	38.89	39.11	38.90	38.85	38.78	0.38	0.150
Final weight (g)	418.76^{d}	419.24^{cd}	418.87^{d}	421.00^{c}	423.64^{bc}	421.12^{c}	426.56^{b}	464.79^{a}	429.89^{b}	1.81	0.038
Total weight gain (g)	379.82^{d}	380.68^{d}	380.11^{d}	382.29^{cd}	384.74^{cd}	382.02^{cd}	387.66^{c}	425.94^{a}	397.77^{b}	3.25	0.016
Weight gain (g/b/d)	13.56^{d}	13.60^{cd}	13.58^{cd}	13.65^{c}	13.74^{c}	13.65^{c}	13.84^{c}	15.21^{a}	14.21^{b}	0.12	0.001
Feed intake (g/b/d)	39.68	39.97	40.45	40.63	40.88	39.72	39.98	40.25	39.95	0.39	0.081
Feed conversion ratio	2.93	2.94	2.98	2.98	2.97	2.91	2.89	2.65	2.81	0.03	0.150
Mortality (%)	5.56	3.33	3.33	4.44	4.44	3.33	3.33	3.33	3.33	0.64	0.000
Finisher (5-8 weeks)											
Initial weight (g)	441.03	441.22	441.10	442.12	441.17	441.55	440.68	441.10	440.96	0.60	0.310
Final weight (g)	1830.69^{f}	1876.58^{e}	1913.00^{cd}	1946.71^{c}	1955.53^{c}	1955.45^{c}	1972.50^{bc}	2045.00^{a}	1965.90^{b}	18.60	0.015
Total weight gain (g)	1389.67^{f}	1435.36^{e}	1472.00^{de}	1504.59^{d}	1514.36^{bc}	1514.90^{bc}	1531.80^{ab}	1604.00^{a}	1524.94^{ab}	20.50	0.001
Weight gain (g/b/d)	49.63^{c}	51.26^{bc}	52.57^{abc}	53.74^{b}	54.08^{b}	54.10^{b}	54.71^{b}	57.29^{a}	54.46^{b}	0.66	0.000
Feed intake (g/b/d)	148.81	148.99	149.20	149.40	150.36	149.87	149.66	151.40	150.13	0.54	0.030
Feed conversion ratio	3.00	2.91	2.84	2.78	2.78	2.77	2.74	2.64	2.76	0.03	0.081
Mortality (%)	3.33	2.22	2.22	3.33	2.33	2.22	3.33	1.11	1.11	1.10	0.150

^{abcd}Mean values in the same row having different superscripts are significantly different ($P<0.05$)

The parameters considered to determine the cost benefit analysis of production are presented in Table 5. Interaction of DL-methionine and sodium sulphate showed significant (P< 0.05) effect on cost of diet, cost of feed consumed, total revenue, benefit and cost benefit ratio at starter phase. Birds fed with diet containing 250 mg/Kg DL-methionine showed higher significant values across dietary levels of sodium sulphate supplementations; 0 mg/kg, 125 mg/kg and 250 mg/kg The results did not show definite pattern; birds fed diet containing 250 mg/Kg DL-methionine with 125 mg/Kg sodium sulphate showed higher significant values of 312.35 ₦/bird and 36.58 ₦/bird for revenue and benefit. Least cost benefit ratio of 7.54 was recorded for birds fed diet containing 250 mg/Kg DL-methionine with 125 mg/Kg sodium sulphate. This implies that supplementation of DL-methionine and sodium sulphate did not has adverse effect on the economics of production of broiler chickens.

The interaction effects of DL-methionine and sodium sulphate at finisher phase followed similar trend with starter phase. The finisher phase showed significant (P < 0.05) effect on cost of diet, cost of feed consumed, total revenue and benefit. Values obtained for birds on 250 mg/Kg DL-methionine with 125 mg/kg sodium sulphate and 250 mg/Kg DL-methionine with 250 mg/kg sodium sulphate showed higher significant (P<0.05) values for cost of diet and cost of feed consumed compared to other dietary groups. Birds fed diet containing 250 mg/Kg DL-methionine with 125 mg/Kg sodium sulphate showed higher significant values of 1431.47 ₦/bird and 650.08 ₦/bird for total revenue and benefit. The significant differences observed for the weight gain as growth response translated to significant effects of parameters for the cost benefit analysis. It is inferred that the nutrient retained was sufficiently utilized for tissue synthesis. This is the pivot for all the parameters considered to evaluate the economic viability using DL-methionine and sodium sulphate. Birds on 250 mg/Kg DL-methionine with 125 mg/kg sodium sulphate recorded the lowest non-significant (P>0.05) value of 1.20 for cost benefit ratio. The result of feed cost as percentage of total cost of production varied between 74.43 – 75.73% for starter and 87.81 - 88.54% for finisher. This observation did not support the findings of Singh *et al.* (2010) who reported 56.23 - 70% as the range for feed cost in broiler production. However, feed cost as percentage of total cost of production as observed at the starter phase in this study corroborated the report of Aduku (2004) who reported 80% cost of production.

Table 5: Interactive effect of varying levels of DL-methionine and sodium sulphate on cost benefit analysis of broiler chickens.

DL-methionine (mg/kg)	**0.00**			**125**			**250**			
Sodium sulphate (mg/kg)	**0**	**125**	**250**	**0**	**125**	**250**	**0**	**125**	**250**	**SEM**
Parameters	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	
Starter (0-4 weeks)										
Cost of diet (₦/kg)	73.69^{c}	74.39^{c}	75.09^{bc}	75.38^{bc}	76.08^{b}	76.78^{ab}	77.07^{a}	77.77^{a}	78.47^{a}	0.13
Cost of feed consumed (₦/bird)	81.87^{c}	83.26^{bc}	85.04^{ab}	85.76^{ab}	87.09^{a}	85.38^{ab}	86.28^{a}	87.65^{a}	87.78^{a}	0.84
Operational cost (₦/bird)	28.12	28.12	28.12	28.12	28.12	28.12	28.12	28.12	28.12	0.00
Cost of production (₦/bird)	109.99	111.38	113.16	113.88	115.21	113.50	114.40	115.77	115.90	0.84
Feed cost (%)	74.43	74.75	75.15	75.31	75.59	75.22	75.42	75.71	75.73	0.04
Cost of DOC (₦/bird)	160.00	160.00	160.00	160.00	160.00	160.00	160.00	160.00	160.00	0.00
Total cost (₦/bird)	269.99	271.38	273.16	273.88	275.21	273.50	274.40	275.77	275.90	0.20
Total revenue (₦/bird)	293.13^{d}	293.47^{d}	293.21^{d}	294.70^{cd}	296.55^{c}	294.79^{cd}	298.59^{bc}	312.35^{a}	304.92^{b}	1.27
Benefit (₦/bird)	23.14^{cd}	22.09^{d}	20.05^{e}	20.82^{de}	21.34^{d}	21.29^{d}	24.19^{c}	36.58^{a}	29.02^{b}	0.10
Cost: Benefit ratio	11.67^{b}	12.29^{ab}	13.62^{a}	13.15^{a}	12.90^{ab}	12.85^{ab}	11.34^{b}	7.54^{d}	9.51^{c}	0.07
Finisher (5-8 weeks)										
Cost of diet (₦/kg)	75.60^{e}	76.30^{de}	77.00^{cd}	77.29^{c}	77.99^{b}	78.69^{b}	78.98^{b}	79.68^{a}	80.38^{a}	0.13
Cost of feed consumed (₦/bird)	314.99^{e}	318.30^{de}	321.74^{cd}	323.33^{c}	328.35^{b}	330.22^{b}	330.96^{b}	337.67^{a}	337.90^{a}	1.17
Operational cost (₦/bird)	43.72	43.72	43.72	43.72	43.72	43.72	43.72	43.72	43.72	0.00
Cost of production (₦/bird)	358.71	362.02	365.46	367.05	372.07	373.94	374.68	381.39	381.62	1.17
Feed cost (%)	87.81	87.92	88.04	88.09	88.25	88.31	88.33	88.54	88.54	2.10
Cost of 28-days old (₦/bird)	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	0.00
Total cost (₦/bird)	758.71	762.02	765.46	767.05	772.07	773.94	774.68	781.39	781.62	0.06
Total revenue (₦/bird)	1281.49^{d}	1313.61^{cd}	1339.44^{bc}	1362.70^{b}	1368.87^{b}	1368.82^{b}	1380.74^{b}	1431.47^{a}	1376.16^{b}	6.01
Benefit (₦/bird)	522.78^{c}	551.59^{bc}	573.98^{bc}	595.65^{b}	596.80^{b}	594.88^{b}	606.06^{ab}	650.08^{a}	594.54^{b}	2.39
Cost: Benefit ratio	1.45	1.38	1.33	1.29	1.29	1.30	1.28	1.20	1.31	0.00

^{abcd}Mean values in the same row having different superscripts are significantly (P<0.05) different

The interaction effect of varying levels of DL-methionine and sodium sulphate on carcass characteristics of broiler chickens is presented in Table 6. The result revealed that live weight, plucked weight, eviscerated weight, breast, back, drum stick, gizzard and liver were significantly ($P<0.05$) affected by interaction effect of DL-methionine and sodium sulphate. Values obtained increased significantly ($P<0.05$) for parameters measured with increasing level of DL-methionine across dietary levels of sulphur supplementation. The result did not follow a definite pattern, with birds fed 250mg/kg DL-methionine with 125 mg/kg sodium sulphate (D8) shown high ($P<0.05$) significant values of 2076.31g,1962.81g and 1575.66g for live weight, plucked weight and eviscerated weight respectively. Higher statistical values of 18.72%, 13.90%, 10.84% and 3.81% were recorded for breast, back, drumstick and gizzard respectively in the birds fed diet supplemented with 250 mg/kg DL-methionine and 125 mg/kg sodium sulphate (D8). This findings supported the work of Ojano-Dirain and Waldroup (2002) who observed significant improvement in dressing percentage and breast meat yield when broilers were fed supplemental DL-methionine higher than NRC recommended level. More recently, the sensitivity of breast meat in broiler to dietary methionine has repeatedly been demonstrated (Huyghebaert *et al.*, 1994; Schutte and Pack, 1995). Similarly, improved carcass yield observed in this study agreed with findings of Chattopadhyay *et al.* (2006) who reported improved dressing percent, thigh and breast yield in broilers with DL-methionine supplementation at rate of 15g/kg. Cut parts; wing, thigh, neck, shank and head were not significantly influenced by the dietary treatments. Similarly, organs; lung, kidney, heart, intestine and spleen were not influenced by DL-methionine and sodium sulphate supplementation.

Table 6: Interaction effect of varying levels of DL-methionine and sodium sulphate on carcass characteristics of broiler chickens.

DL-methionine levels (mg/kg)	**0.00**			**125**			**250**				
Sodium Sulphate levels (mg/kg)	**0**	**125**	**250**	**0**	**125**	**250**	**0**	**125**	**250**	**SEM**	**p-value**
Parameters											
Live weight (g)	1751.25^{bc}	1782.20^{bc}	1760.97^{bc}	1834.79^{b}	1950.83^{ab}	1922.67^{ab}	1860.28^{b}	2076.31^{a}	1942.88^{ab}	28.21	0.003
Plucked weight (g)	1649.03^{c}	1670.20^{c}	1662.90^{c}	1715.09^{bc}	1839.36^{ab}	1837.10^{ab}	1805.95^{ab}	1962.81^{a}	1855.16^{ab}	18.71	0.016
Eviscerated weight (g)	1275.74^{c}	1263.30^{c}	1252.35^{c}	1457.17^{b}	1457.03^{b}	1454.60^{b}	1418.24^{b}	1575.66^{a}	1466.29^{b}	53.03	0.013
Dress weight (%)	72.82^{bc}	70.90^{c}	71.12^{c}	73.97^{b}	74.69^{b}	75.07^{ab}	73.58^{b}	75.90^{ab}	82.15^{a}	2.42	0.001
Cut parts (percentage live weight)											
Wing (%)	6.21	6.67	6.49	6.44	6.37	7.34	7.27	7.74	7.35	0.13	0.160
Thigh (%)	9.05	9.16	9.14	9.15	9.58	9.69	9.59	10.45	9.61	0.09	0.210
Breast (%)	16.02^{c}	16.11^{c}	16.37^{c}	16.57^{bc}	16.91^{bc}	17.57^{ab}	17.62^{ab}	18.72^{a}	17.72^{ab}	0.09	0.001
Back (%)	12.13^{d}	12.32^{cd}	12.33^{cd}	12.84^{bcd}	12.74^{cd}	13.15^{abc}	13.19^{abc}	13.90^{a}	13.56^{ab}	0.12	0.000
Neck (%)	3.05	3.45	3.22	3.23	3.35	3.45	3.63	4.59	3.73	0.10	0.080
Shank (%)	4.04	4.05	4.11	4.29	4.48	4.37	4.74	5.72	4.65	0.08	0.001
Head (%)	3.05	3.12	3.12	3.28	3.39	3.52	3.56	3.87	3.62	0.04	0.081
Drum stick (%)	9.01^{d}	9.15^{cd}	9.19^{cd}	9.33^{bcd}	9.42^{bcd}	9.52^{bc}	9.75^{bc}	10.84^{a}	10.42^{ab}	0.04	0.000
Organ weight (percentage live weight)											
Empty Gizzard (%)	2.11^{d}	2.29^{c}	2.56^{c}	3.06^{bc}	3.09^{b}	3.14^{b}	3.56^{ab}	3.81^{a}	3.63^{ab}	0.11	0.001
Liver (%)	1.16^{c}	1.23^{c}	1.83^{b}	1.65^{b}	2.04^{ab}	2.39^{ab}	2.11^{ab}	2.68^{a}	2.67^{a}	0.14	0.013
Lung (%)	0.60	0.62	0.64	0.62	0.65	0.72	0.70	0.83	0.69	0.03	0.190
Kidney (%)	0.25	0.29	0.31	0.35	0.35	0.35	0.38	0.47	0.35	0.02	0.210
Heart (%)	0.40	0.42	0.44	0.44	0.51	0.50	0.58	0.62	0.58	0.03	0.000
Intestine (%)	7.13	7.33	7.52	7.62	7.63	7.55	7.83	7.89	7.45	0.17	0.080
Abdominal fat (%)	1.11	1.03	1.35	1.19	1.31	1.65	1.53	1.23	1.56	0.20	0.090
Spleen (%)	0.11	0.14	0.13	0.14	0.14	0.13	0.15	0.15	0.15	0.02	0.080

^{abcd}Mean values in the same row having different superscripts are significantly different (P<0.

CONCLUSION AND RECOMMENDATIONS

Results from this study revealed that supplementation of DL-methionine and sodium sulphate in diet of broiler chickens had no deleterious effect. Supplementation of DL-methionine and sodium sulphate showed improved growth response in broiler chickens. Supplementation at level of 250 mg/kg DL-methionine and 125 mg/kg sodium sulphate reflected high significant values for growth performance and carcass yield. However, studies should be geared toward investigating other chelated sulphur sources for efficient inclusion and utilization of cassava in diets for broiler chickens.

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