sciendo

Archiva Zootechnica 26:2, 20-35, 2023
DOI: 10.2478/azibna-2023-0012

Performance, haemato-biochemical indices and antioxidants status of broiler chickens fed diet with low metabolizable energy supplemented with graded levels of Guanidino Acetic Acid (GAA)

Akinlolu Ayeni, Damilola Ogungnebro *, Oladayo Afolabi, Olubunmi Aladenola, Fisayo Aguda, Mojolajesu Ayoade, Tolulope Agboola, Opeyemi Adeola and Gbenga Onibi

*corresponding author: ogungbenrodc@futa.edu.ng

Department of Animal Production and Health, Federal University of Technology Akure, Nigeria

ABSTRACT

The growth, haemato-biochemical indices, and antioxidant status of broiler chickens fed varying levels of Guanidino Acetic Acid (GAA) were evaluated over the course of an eight-week feeding trial. In low ME (2700Kcal/kg) basal diets, the Guanidino Acetic Acid was supplemented at 0, 0.6, and 1.2g/kg, designated as diets I, II, and III, respectively. The average final weight of chickens fed diet III was the highest at the end of the feeding trial. The best feed conversion ratio was observed in birds fed diet III. The packed cell volume and haemoglobin were highest in birds fed diet I. Significantly higher Cholesterol and Albumin were recorded in diets III and II, respectively. All the antioxidant parameters were significant except Catalase. The glutathione peroxidase increased with increased Guanidino acetic Acid supplementation while Catalase reduced with increased GAA supplementation. According to the findings of this study, Guanidino Acetic Acid improved the health of broilers while having no negative effects on their health. It is therefore concluded that supplementation of Guanidino Acetic Acid at 1.2g/kg with low metabolizable energy promoted superior growth effect of the chickens and also reduce cost of production.

Keywords: antioxidant, performance, guanidino acetic acid, metabolizable energy, serum biochemical indices

INTRODUCTION

Nutritionists have been constrained in their efforts to find means of lowering the cost of final feed due to the unstoppable rise in the cost of dietary energy sources. Low-quality energy feed fixings have occasionally been selected as a solution to the problem (Salem and Smith, 2008). Such practices can bring about poor performance associated with body weight gain (BWG), feed conversion ratio (FCR) with participation low proficiency of the birds (Ahiwe et al., 2018). The available option could be to reduce (adjust) the amount of energy in the bird's diet in order to increase energy efficiency. However, there are physical and biological limitations to this kind of interaction. It is important to note that modern broilers have a very high rate of ongoing development, which contributes to shorter developing periods. Again, birds on such weight-control plans have limited feed intake (FI) because body growth and improvement of the digestive system are not exactly parallel. It is important to keep in mind that the birds are unable to endure FI beyond a certain energy level, so this significance of higher or lower dietary energy needs to be carefully considered because it further affects the rate of productive development (Dozier et al., 2007; Tallentire et al., 2018).The nutrients in a bird's diet play a significant role in maintaining the digestive system's integrity, despite the fact that the gastrointestinal system of a bird is dependent on a few factors (Adedokun and Olejede, 2019).

Guanidinoacetic acid is the N-amidino derivative of glycine. It is a conjugate acid of a guanidinoacetate. It is a tautomer of a guanidinoacetic acid zwitterion. Guanidoacetic acid is a metabolite in the Urea cycle and metabolism of amino groups, and in the metabolic pathways of several amino acids. This includes glycine, serine, threonine, arginine and proline metabolism. Guanidinoacetic acid is also a precursor of creatine, an essential substrate for muscle energy metabolism. Dietary supplementation of Guanidinoacetic Acid (GAA) as creatine antecedent was displayed to have saving impacts for arginine due to the restricted level, particularly in starter and grower diets based on consumed maize and soybean meal, which increase arginine accessibility in broiler chickens (Baker, 2009). Mousavi et al. (2013) revealed that supplemental GAA further developed energy efficiency by reducing caloric usage per kg body weight gain BWG and additional carcass weight. Indeed, GAA supplementation (0.06%) has been shown to reduce the effects of lower dietary metabolizable energy (up to 95% of the Cobb 500 recommendation) on broiler chicken growth (Mousavi et al., 2013). The majority of studies examining the effects of dietary GAA have focused on meat quality or growth performance; However, despite the fact that a few recent studies have examined the relationship between energy and GAA, the impact of dietary GAA on low dietary energy has received either no or very little attention. As a result, the current study hypothesized that broiler chicken

growth performance, blood, serum, and antioxidant properties could be affected by GAA supplementation in low-energy diets by either sparing Arginine or improving cellular energy status. As a result, the purpose of this study was to determine how Arbor Acres broiler chicken's growth performance, blood, serum, and antioxidant properties were affected by GAA and reduced energy levels in their diets.

MATERIALS AND METHODS

Experimental Site

The study was carried out at the Poultry Unit of Teaching and Research Farm (Livestock) of the Federal University of Technology, Akure, Nigeria, which possesses an area of around 5 km2, lies between Scopes 7° 17'0''N - 7° 19'0''N and Longitudes 5° 7' 0''E - 5° 9'0''E. The study area has an elevation between 375 and 381 meters above mean ocean level. The region has dry (November to March) and wet (April to October) seasons, with a mean annual precipitation of between 1000 and 1500 millimetres. According to Akinbode et al., (2009) the annual mean temperature ranges from 21.9 to 30.40 degrees Celsius. Humidity levels moderately rise during the wet season and fall during the dry season, with annual values ranging from 39.1 to 98.2 percent. 2008). The thick timberland depicts the vegetation as equatorial rain forest.

Collection of Guanidino Acetic Acid (GAA) and Diet Preparation

The manufacturer (Alzchem, Germany) supplied the Creamino, a source of Guanidino Acetic Acid (GAA). A straight diet was formulated for the birds containing 2700 kcal/kg of energy and 21% Crude Protein as shown in Table 1.

The diets were fed throughout the duration of the experiment which spanned for 56 days. The straight diet was divided into three portions, with 0.6 and 1.2 g/kg of GAA added to the remaining two portions, respectively, while the first portion served as the control.

In a Completely Randomized Design, the birds were divided into three (3) treatments at random. There were ten (10) birds in each of the five (five) replicates for each treatment. A sum of one hundred and fifty (150) day-old Arbor Acres broiler chicks were used for the experiment.

The chicks were fed their respective experimental diets ad libitum for 56 days during this time. Both the daily feed intake and the weekly weight gain were measured and recorded.

Table 1. Percentage composition of basal diet

Ingredients	Quantity (kg)
Maize	48.10
Soybean meal	9.93
Wheat offal	12.00
Groundnut cake	20.50
Dicalcium phosphate	1.20
Fish meal	5.00
Limestone	1.00
Bone meal	1.50
Lysine	0.12
Methionine	0.10
Salt	0.30
Premix	0.25
Total	**100**
Calculated Composition	
Metabolisable Energy (kcal/kg)	2700
Crude Protein (%)	21.40
Crude Fibre (%)	4.24
Calcium (%)	1.40
Available phosphorus (%)	0.68
Methionine	0.44
Lysine	1.13

The chickens were starved overnight so as to empty the crop, weighed and sacrificed followed by severing the jugular vein. Blood samples were collected into labelled ethylenediaminetetra-acetic (EDTA) bottles (processed for haematology) and plain test tubes for serum biochemical indices and antioxidant parameters. The haematology analysis was done using automated haematology analyzer (BIOBASE, BK-6400). For the serum analysis, blood samples collected in test tubes were allowed to stand in slanting position for about 1 day. The blood was then centrifuged to separate the serum from whole blood. The serum was harvested (using a pipette) into cryopreservation containers and then analyzed for the biochemical parameters (ALT, cholesterol, creatine, total protein, albumin and globulin). The serum antioxidant GSH-Px and SOD activity was determined according to the method described by Paglia and Valentine (1976) using a commercially available enzyme kit (Ransel, RANDOX/RS-504 by Randox Laboratories, Crumlin, UK) and according to Nishikimiet al. (1972) using the commercially available enzyme kit (Ransod, RANDOX/SD-125 supplied by Randox Laboratories, Crumlin, UK) respectively. The organ and carcass were weighed and recorded.

The means were separated using Duncan's multiple range test from the same software package, and the experiment's data were subjected to analysis of variance using SPSS version 25.

RESULTS

Growth performance of broiler chickens fed diet supplemented with GAA

Table 2 represent the performance of broiler chickens fed graded levels of GAA.

Table 2. Growth performance characteristics of broiler fed diets containing low dietary metabolizable energy and guanidino acetic acid supplementation

Parameters	DIET I	DIET II	DIET III	
Days 1-21	**Mean ± SE**	**Mean ± SE**	**Mean ± SE**	**p-value**
Initial Weight (g/bird)	38.60 ± 0.20	38.67±0.13	38.67±0.13	0.943
Final weight (g/bird)	525.62 ± 22.23^{a}	419.02±28.80^{b}	525.73±15.39^{a}	0.004
Weight gain (g/bird)	487.02±22.25^{a}	380.35±28.83^{b}	487.06±15.53^{a}	0.004
Total feed consumed (g/bird)	948.90±50.79^{a}	783.99±10.73^{b}	954.37±14.92^{a}	0.028
Feed conversion ratio	1.95±0.02	2.09±0.16	1.96±0.03	0.464
Days 1-42				
Initial Weight (g/bird)	38.60±0.20	38.67±0.13	38.67±0.13	0.943
Final weight (g/bird)	1348.97±34.41^{a}	1175.67±26.08^{b}	1307.35±22.14^{a}	0.011
Weight gain (g/bird)	1310.36±34.36^{a}	1137±26.08^{b}	1268.68±22.26^{a}	0.011
Total feed consumed (g/bird)	3718.63±135.70^{a}	3070.72±177.16^{b}	3482.82±109.27^{a}	0.049
Feed conversion ratio	2.85±0.17	2.71±0.18	2.74±0.04	0.787
Days 1-56				
Initial Weight (g/bird)	38.60±0.20	38.67±0.13	38.67±0.13	0.943
Final weight (g/bird)	2008.96±74.94^{ab}	1839.17±117.76^{b}	2203±37.18^{a}	0.058
Weight gain (g/bird)	1970.36±74.90^{ab}	1800.50±117.65^{b}	2164.50±37.07^{a}	0.057
Total feed consumed (g/bird)	5675±250.11^{a}	4907.36±243.61^{b}	5510.32±100.51^{ab}	0.089
Feed conversion ratio	2.90±0.23	2.77±0.32	2.55±0.07	0.582

The results at 1-21 days shows significant effect ($p<0.05$) across the dietary treatments. Birds fed 1.2g/kg GAA had an improved average final weight (FW), average weight gain (WG) but birds fed control had best feed conversion rate (FCR). At day 42, birds fed diet I showed the best FW and weight gain compared to broiler chickens fed the supplemental diets. Though there was no significant ($p>0.05$) difference in FCR, birds fed diet containing 0.6g/kg GAA showed the best FCR compared with of broiler chickens fed control diet. At day 56, birds fed diet containing 1.2g/kg level of GAA showed the best FW and weight gain compared to broiler chickens given diet I and 0.6g/kg. There was no significant ($p>0.05$) difference in FCR but broiler chickens fed diet containing 1.2g/kg GAA showed the best FCR.

Haematological parameters of broiler chickens fed diet supplemented with GAA

Table 3 presents the haematological parameters of broiler chickens fed diets containing varying levels of GAA supplementation.

Table 3. Hematology parameters of broiler fed diets containing low dietary metabolizable energy and guanidino acetic acid supplementation

Parameters	DIET I	DIET II	DIET III	
	Mean ± SE	Mean ± SE	Mean ± SE	p-value
PCV (%)	29.67±0.33[a]	27.67±0.67[ab]	26.00±1.00[b]	0.031
RBC (x10^ 6/L)	14.63±2.91	11.87±0.88	13.73±0.39	0.561
MCHC (g/dl)	33.25±0.08	33.25±0.08	33.20±0.01	0.814
MCV (fL)	22.26±5.03	23.56±1.74	19.00±1.17	0.598
MCH (pg/cell)	7.42±1.68	7.85±0.58	6.33±0.39	0.598
Hamoglobin (Hbg/dl)	9.89±0.11[a]	9.22±0.22[ab]	8.66±0.33[b]	0.031
White blood cell (x 10^ 9/L)	1.90±0.26	1.73±0.12	1.93±0.24	0.792
Granulocyte (%)	41.33±2.91	36.67±2.40	43.33±6.36	0.559
Lymphocyte (%)	56.67±1.76	62.67±2.67	50.00±6.11	0.159
Monocyte (%)	2.00±1.15	2.27±1.07	3.33±1.33	0.296

For all the parameters measured, packed cell volume and haemoglobin were significantly ($p<0.05$) influenced by the dietary treatments. Highest pack cell volume and haemoglobin were recorded in birds fed diet I, while the lowest Pack cell volume and haemoglobin were recorded in birds fed diet III.

Serum biochemical indices and antioxidant properties of broiler chicken fed diet supplemented with GAA

The serum biochemical indices and antioxidant properties of broiler chicken fed diet supplemented with GAA is presented in Table 4. All serum biochemical parameters measured were not significantly ($p<0.05$) influenced by the dietary treatments with exception of cholesterol and albumin.

Table 4. Serum and antioxidant parameters of broiler fed diets containing low dietary metabolizable energy and guanidino acetic acid supplementation

Parameters	DIET I	DIET II	DIET III	
	Mean ± SE	Mean ± SE	Mean ± SE	p-value
AST (IU/L)	71.95±3.44	77.90± 2.02	86.95±8.28	0.213
ALT (IU/L)	46.15±0.66	45.75±1.36	46.85±0.61	0.717
Cholestrol (mmol/L)	31.08±0.03[a]	31.35±0.06[a]	33.55±0.06[b]	0.001
Creatine (mmol/L)	0.33±0.03	0.35±0.09	0.40±0.01	0.167
Total protein (g/L)	3.44±2.02	3.27±1.15	3.33±2.54	0.833
Albumin (g/L)	1.54±0.46[a]	1.15±0.81[b]	1.27±0.46[b]	0.010
Globumin (g/L)	1.90±1.56	2.12±1.96	2.06±3.00	0.784
Antioxidant				
Catalase (kU/ml)	142.25±22.76	102.18±10.38	91.76±19.60	0.202
GSH (umole/mg protein)	142.28±2.17[b]	145.41±2.53[b]	156.53±4.33[a]	0.042
SOD %	70.85±0.28[b]	74.76±0.28[a]	70.85±0.28[b]	<0.001

The highest cholesterol was observed in birds fed diet III while the highest albumin was recorded in birds fed diet I. The lowest cholesterol and albumin were observed in birds fed diets I and II, respectively.

All antioxidant parameters measured were significantly ($P<0.05$) influenced by the dietary treatments except catalase. The highest GSH and SOD were recorded in birds fed diet II and III. The lowest GSH and SOD were recorded in birds fed diet I.

Carcass characteristics of broiler chickens fed diet supplemented with GAA

Table 5 presents some selected carcass characteristics of broiler chickens fed diets containing varying levels of GAA supplementation.

Table 5. Selected carcass and organ characteristics of broiler fed diets containing low dietary metabolizable energy and guanidino acetic acid supplementation

Parameters	DIET I	DIET II	DIET III	
	Mean ± SE	Mean ± SE	Mean ± SE	p-value
Dress weight (%)	85.99±3.29	89.94± 0.49	86.53±0.13	0.460
Eviscerated weight (%)	70.16±1.87	71.27±1.22	72.95±1.16	0.444
Thigh (g/bird)	105.07±3.49	108.89±7.59	106.73±2.82	0.841
Drumstick (g/bird)	101.69±3.68	101.54±1.04	108.76±3.96	0.871
Chest (g/bird)	161.57±21.95	183.94±13.35	193.25±2.55	0.262
Back (g/bird)	125.45±8.63	123.85±5.27	133.41±0.66	0.553
Abdominal fat (g/bird)	2.19±2.19	8.22±2.74	4.13±2.84	0.339
Heart (g/bird)	4.15±0.47	4.42±0.34	3.75±0.48	0.583
Gizzard (g/bird)	18.61±1.62[b]	25.06±1.07[a]	18.17±2.15[b]	0.047

For all the parameters measured, only gizzard was significantly ($p<0.05$) influenced by the dietary treatments. At day 56, birds fed diet containing

0.6g/kg level of GAA showed the best DWT and gizzard weight as compared to birds fed control diet and 1.2g/kg GAA.

Economic evaluation of broiler chickens fed diet supplemented with GAA

The economical evaluation of broiler chicken fed diet supplemented with GAA is presented in Table 6.

Table 6. Economic evaluation of broiler fed diets containing low dietary metabolizable energy and guanidino acetic acid supplementation

Parameters	DIET I	DIET II	DIET III
Initial Weight (g/bird)	38.60	38.67	38.67
Final Weight (kg/bird)	2.008.96	1.839.17	2.203.00
Weight Gain (kg/bird)	1.97	1.80	2.16
Total Feed Consumed (kg/bird)	5.68	4.91	5.51
Cost of Feed /Kg (₦/kg)	271.18	280.80	289.80
Total Cost of Feed Intake (₦)	1544	1,379	1,597
Cost of Feed /Kg Gain (₦/kg)	781.76	766.11	739.35
% cost reduction of bodyweight/kg gain	-	2.00%	5.42%

The economical evaluations were calculated according to the input-output, economic efficiency and relative economic efficiency. Considering the raw material price situation in the first half of 2022 the feed formulations amounted to $3.41, $3.04 and $3.53 in respective of the diets. Supplementing GAA, at 0.6g/kg and 1.2g/kg per tonne of feed, increased the cost of diets by $0.02 and $0.06 Naira per kg of feed respectively compared with the control diet.

DISCUSSION

Effect of guanidinoacetic acid supplementation on the growth performance

Guanidino Acetic Acid (GAA) is the immediate precursor of Creatine (Cr) that requires just a methyl-group transfer from S-adenosylmethionine (SAM), and doesn't consume arginine, a fundamental amino acid for birds. Dietary GAA improve cellular bioenergetics by stimulating creatine (Ostojic, 2015), it very well may be considered that dietary GAA have several effects on broiler performances relying upon the energy level of the diet. In the present study, the impact of GAA supplementation was found in final weight and weight gain at 21 and 42 days yet an improvement in FCR was seen at 1-42 days and 1-56 days, this is due to the fact that the broiler chicks used the energy in the feed

for growth at the starting phase while the energy in the feed was used for muscle deposition at the finisher stage.

The response of growing broilers to energy density is variable and may depend on several factors, such as bird gender, breed, age, and so on, despite the fact that it is common knowledge that a low level of energy has a negative impact on growth performance. including the density of amino acids, the type of fat, the amount of fat included, and the type and amount of fiber in diets (Classen, 2017). Despite eating almost, the same amount of food quantity throughout this experiment, birds fed diet III (2700kcal with 1.2g/kg of GAA) gained more weight than birds fed the control diet or another test diet (2700kcal with 0.6g/kg of GAA) at 1-21 days and 42-56 days, respectively (Table 2). In agreement with Mousavi et al. (2013) GAA supplementation at 1.2g/kg resulted in a 9.71 percent increase in final body weight in the current study and this is agreement with Mousavi et al. (2013), who reported that GAA reduced calorie intake per kg of BWG and carcass weight by 2.9% and 3.7%, respectively, to increase energy utilization efficiency.

At 0.6g/kg and 1.2g/kg, GAA supplementation reduced feed intake by 13.53 percent and 2.90 percent, respectively, in this study. This response could have been caused by either a negative effect of GAA on voluntary feed intake or improved energy utilization in chickens fed diets with GAA supplements. Mousavi et al. (2013) reported a similar effect despite the fact that their study found no significant differences between the GAA-treated and control groups ($P = 0.09$). According to Lemme et al. (2010), it has also been discovered that turkeys receiving GAA supplements also consume less feed.

At the conclusion of the trial, the FCR of birds fed diets containing GAA supplemented at 0.6g/kg, 1.2g/kg, and control was found to be 2.55, 2.77, and 2.90, respectively. This indicates that, at 0.6g/kg and 1.2g/kg, GAA supplementation decreased the FCR by a difference of 4.48 percent and 11.03 percent, respectively. This result backs up the findings of Ringe et al. (2007), who found that a 0.6g/kg dose of GAA supplementation increased FCR by as much as 7 points in a vegetable-based diet compared to the control.

It is not entirely clear how GAA influences broiler performance. Guanidino acetic acid (GAA) is a characteristic natural precursor of creatine, which is engaged with cell energy metabolism, especially in tissues with high and differing energy request like skeletal muscle (Michiels et al., 2012). GAA may replenish creatine reserves in fast-growing animals fed only vegetables without creatine, enhancing tissue energy metabolism and body growth. Amino acid metabolism may be associated with a different GAA mode of action. According to Baker (2009), arginine, one of the potentially limiting amino acids in low-protein broiler diets, may be spared by GAA supplementation because GAA is synthesized in vivo from glycine and arginine. Certainly, Dilger et al. 2013) showed that GAA supplementation particularly further developed development of chickens took care of arginine-

inadequate casein-based diets. In practical-type diets with moderate arginine deficiency, there was no development reaction to GAA, yet feed conversion was significantly improved.

This study's findings indicate that feed conversion ratio in broilers is a more sensitive indicator of nutrient adequacy than growth rate. Because of this, the financial implications of this feeding strategy merit further investigation. Feed formulations for each diet came to $3.41, $3.04, and $3.53, respectively, when taking into account the state of the price of raw materials in the first half of 2022. At 0.6g/kg and 1.2g/kg per tonne of feed, supplementing with GAA resulted in contributions of 9 and 18 Naira per kg of feed, respectively. This therefore implies that if $2000 were used for feeding, GAA supplementation will reduce the cost by 2% ($1960) when supplemented at 0.6g/kg and by 5.42% ($1892) when supplemented at 1.2g/kg. At the end of the study, the profit margin generated by the birds fed the supplemented diet was 2.00% and 5.42%, respectively, over the birds fed the control diet. Roland et al. (2000) have made similar observations; Liu et al. (2005); Onu et al. (2010); Selim et al. (2016). They came to the conclusion that, according to economic analysis, feeding different feed additives to broiler diets was more profitable than feeding unsupplemented diets.

Effect of guanidinoacetic acid supplementation on the haematological parameters

Typically, an animal's health status is evaluated using the results of haematology and serum analysis. According to Khan and Zafar (2005), haematological and serum parameters have been shown to be useful indicators of an animal's physiological state, and changes in either of these parameters are crucial for determining how an animal will respond to various physiological conditions. The dietary treatments had significant effects on PCV and haemoglobin in this study. The bird's pack cell volume decreased as the supplementation of GAA increased, but this did not indicate a potential health risk. According to Oloruntola et al., the value fell within the normal range of 26.00% to 29.67% for broiler chicken (2016).

Iron participates as a vital constituent in haemoglobin synthesis and a deficiency in iron may be accompanied by anaemia (Camaschella, 2017). In this study, creatine level was numerically increased by GAA supplementation while haemoglobin concentration was significantly ($p<0.05$) reduced by the dietary GAA addition. This finding is in line with the study of Jurkovitz et al. (2003) who reported that anaemia was prevalent in patient with high serum creatine level.

The birds' haemoglobin levels ranged from 8.66 to 9.89 g/dl, which is lower than the range of 11.60 to 13.68 g/dl that was reported by Wikivet (2013). Haemoglobin is a pigment in the blood that carries oxygen. Its high concentration indicates that it has a good capacity for carrying oxygen to

various parts of the body, which helps animals live healthy lives. The results of this study, which found haemoglobin levels below the normal range, demonstrated the opposite. It was hypothesized that GAA could function as an antioxidant in the blood to safeguard the structure of the erythrocyte membrane and increase the deformability and transportation capacity of erythrocytes, thereby lowering RBC counts and, in turn, haemoglobin. The dietary treatment had no significant effects on MCHC, MCV, MCH, white blood cells, granulocytes, lymphocytes, or monocytes.

Effect of guanidinoacetic acid supplementation on the biochemical parameters

Except for cholesterol and albumin, there was no significant difference between the treatment means in any of the serum biochemical indices measured in this study. Cholesterol is a different type of lipid that is carried throughout the body by lipoproteins. Abundance of cholesterol is associated with coronary disease which is because of the aggregation of cholesterol on the walls of the artery thusly causing the limiting of the veins from there on lessening the progression of blood into the heart (Oloruntola et al., 2019). According to Wikivet (2012), the cholesterol levels observed in this study ranged from 31.08 to 33.55 mmol/L, which is within the normal range for broiler chicken cholesterol (31.30 to 32.4 mmol/L). This suggests that the broiler chickens' GAA supplementation did not cause any cardiovascular problems.

The total protein levels that were observed during this trial ranged from 3.44 to 3.27 g/dl, which is lower than the usual range of 4.63 to 4.81 g/dl (Wikivet 2012). This could have been caused by the feed's low protein content or by the process of analyzing the serum sample. According to Vaughn and Beckel (2012), albumin has been shown to aid in blood clotting in livestock. The higher the albumin content of the blood, the better the ability to coagulate and prevent haemorrhage. However, according to Mitruka and Rawnsley (1977), the albumin level found in this study, 1.15-1.54 g/L, falls within the normal range of 2 to 3 g/dl. Lee et al., 2021) announced that globulin helps contamination counteraction in birds. Adegbenro et al., (2016) also hypothesized that decreased globulin levels could increase pig mortality; this may also hold true for the monogastric broiler chicken used in this study.

ALT and AST are important indicators used to evaluate an animal's liver condition (Agbede et al., 2011). The fact that the means of these variables did not differ significantly suggests that the experimental diets did not pose any health risks to the birds, particularly their livers. The kidney's condition and functions can be determined by measuring the creatinine level. According to Oloruntola et al., (2019) the birds in this study had creatinine levels between 0.12 and 0.23 mg/dl, which is within the normal range. High creatinine level might signify early indication of kidney breaking down, while a low creatinine

level can mean a lower bulk brought about by an illness, like strong dystrophy, or by maturing. As a result, the birds' kidneys functioned normally when fed the supplemented test diets.

Effect of guanidinoacetic acid supplementation on the antioxidant parameters

The first level of defense in the antioxidant system of animal cells are antioxidant enzymes. An important indicator of the antioxidant capacity of animal tissue are antioxidant enzymes like catalase, glutathione, and superoxide, which are endogenously regulated antioxidant mechanisms that are synthesized. In the current study, birds fed the GAA-supplemented diet had higher liver GSH activity and lower liver SOD activity than those fed the GAA-supplemented diet. Although there is a lack of information regarding the effects of exogenous GAA on the oxidant-antioxidant systems of humans and animals, the fact that GAA contains a guanidinium ion with a conjugate base, effectively providing an electron, suggests that it may have an effect on the oxidant-antioxidant systems of animals. As a result, higher concentrations of GAA may hinder antioxidant capacity and produce a hydroxyl radical (Hiramatsu 2003). One of the most important antioxidant enzymes, catalase is responsible for the two-step breakdown of two molecules of hydrogen peroxide into one molecule of oxygen and two molecules of water (Dringen et al., 2005). CAT deficiency obliterates the cell layers. It causes pain, gray hair, and lipid peroxidation, which can lead to diabetes, heart attack, and high bad cholesterol ratios. The birds fed the supplementary diet did not suffer any condition related to high or low CAT concentrations.

Effect of guanidinoacetic acid supplementation on the carcass characteristics

Contradictory findings exist regarding the influence of GAA on carcass parameters. In a study, for instance, birds fed a diet high in GAA produced 30.6% more breast meat than the control group (29.4%) (Michiels et al., 2012). Mousavi and others 2013) observed that carcass characteristics were not affected by dietary GAA inclusion (0% and 0.06%), energy levels and their associations. DeGroot et al. (2019) hypothesized the Arg-sparing effect of GAA more recently, even when added to a diet rich in enough Arg. This might make it possible to use Arg for things other than making creatine, like growing muscles (Edwards et al. 1958). According to DeGroot et al., (2019) the weights of the carcass parameters measured in birds fed diets containing GAA were higher in this study than in those fed control diet this is in support of DeGroot et al. (2019) hypothesis on Arg-sparing hypothesis and contribution to the explanation of the significant increase in carcass yield.

Previous study that elaborates GAA supplementation in pig (O'Quinn et al., 2000) and broilers (Stahl et al., 2003) dietary treatment had little to no

effect on dressing percentage or fat deposition. This contradicts the current study because dressing percentage and abdominal fat increase when GAA was added to the diet.

Other carcass parameters are not affected by the dietary treatment, this is line with Boney et al., 2020 who reported that breast weight and yield in groups supplemented with 0.6g/kg GAA as the main effect in basal diets with or without animal protein source compared to groups without GAA supplementation, while other carcass traits and relative organ weights were unaffected.

CONCLUSION

The study revealed that reduction of dietary energy in diet and supplementing with Guanidino acetic acid (GAA) at 1.2g/kg does not have any adverse effects on the health status of broiler chickens but improved the growth, health status of broiler chickens and also reduce the cost of production

ACKNOWLEDGEMENTS

Our sincere appreciation goes to the Department of Animal Production and Health, Federal University of Technology Akure for allowing us to use their facilities for this study.

REFERENCES

Adedokun, S. A., and Olojede, O. C. (2019). Optimizing gastrointestinal integrity in poultry: the role of nutrients and feed additives.Frontiers in Veterinary Science, 5: 348-349.

Adegbenro, M., Agbede, J. O., Onibi, G. E., and Aletor, V. A. (2016). Composite leaf meal: effects on haematology and biochemical indices of growing pigs. ArchivaZootechnica, 19(2).

Agbede, J. O., Arimah, A. A., Adu, O. A., Olaleye, M. T., and Aletor, V. A. (2011). Growth-enhancing, health impact and bacteria suppressive property of lanthanum supplementation in broiler chicken. ArchivaZootechnica, 14(2), 44-48.

Ahiwe, E. U., Omede, A. A., Abdallh, M. B., and Iji, P. A. (2018). Managing dietary energy intake by broiler chickens to reduce production costs and improve product quality. Animal husbandry and nutrition, 115, 145.

Akinbode, OM., Eludoyin, AO., and Fashae OA. (2008). Temperature and relative humidity distributions in a medium-size administrative town in Southwest Nigeria Environ Manage. 87 (1); 95–105.

Amiri, M., Ghasemi, H.A., Hajkhodadadi, I., and Khaltabadi Farahani, A.H. (2019). Efficacy of guanidinoacetic acid at different dietary crude protein levels on growth performance, stress indicators, antioxidant status, and intestinal morphology in broiler chickens subjected to cyclic heat stress. Anim. Feed Sci. Technology, 254, 114208.

Baker, D. H. 2009. Advances in protein-amino acid nutrition of poultry.Amino Acids, 37: 29–41.

Boney, J.W., Patterson, P.H., and Solis, F. (2020). The effect of dietary inclusions of guanidinoacetic acid on D1-42 broiler performance and processing yields. J. Appl. Poult. Res, 29: 220–228.

Çenesiz, A.A., Yava¸s,˙I., Çiftci,˙I., Ceylan, N., and Ta¸skesen, H.O. (2020). Guanidinoacetic acid supplementation is favourable to broiler diets even containing poultry by-product meal. Br. Poult. Sci, 61: 311–319.

Córdova-Noboa, H.A.; Oviedo-Rondón, E.O.; Sarsour, A.H.; Barnes, J.; Ferzola, P.; Rademacher-Heilshorn, M.; and Braun, U. (2018). Performance, meat quality, and pectoral myopathies of broilers fed either corn or sorghum based diets supplemented with guanidinoacetic acid. Poult. Sci, 97: 2479–2493.

Dozier, W.A., Kidd, M.T., and Corzo, A. (2007). Dietary amino acid responses of broiler chickens. J. Appl. Poultry Res. 17:157-167.

Dringen, R., Pawlowski, P. G., and Hirrlinger, J. (2005). Peroxide detoxification by brain cells. Journal of neuroscience research, 79: 157-165.

Hanganu, A., Bedetti, C., Degroot, C., Mejia-Constain, B., Lafontaine, A. L., Soland, V., and Monchi, O. (2014). Mild cognitive impairment is linked with faster rate of cortical thinning in patients with Parkinson's disease longitudinally. Brain, 137: 1120-1129.

Hiramatsu, M. (2003). A role for guanidino compounds in the brain. Mol Cell Biochem. 244:57–62.

Jurkovitz, C. T., Abramson, J. L., Vaccarino, L. V., Weintraub, W. S., & McClellan, W. M. (2003). Association of high serum creatinine and anemia increases the risk of coronary events: results from the prospective community-based atherosclerosis risk in communities (ARIC) study. Journal of the American Society of Nephrology, 14(11), 2919-2925.Khalil, S., Al-Sagan, A.A., Abdellatif, H.A., Prince, A., and El-Banna, R. (2021). Effects of guanidinoacetic acid supplementation on zootechnical performance and some biometric indices in broilers challenged with T 3 -Hormone. Ital. J. Anim. Sci. 2021, 20, 611–622.

Khan, T. A., and Zafar, F. (2005).Haematological study in response to varying doses of estrogen in broiler chicken.International Journal of Poultry Science, 4(10), 748-751.

Lemme, A., Ringel, J., Rostagno, H.S., and Redshaw, M.S. (2007a). Supplemental guanidino acetic acid improved feed conversion, weight gain, and breast meat yield in male and female broilers. pp 1-4 in Proc. XVI Eur. Symp.on Poultry Nutrition, Strasbourg, France.

Lemme, A., Ringel, J., Sterk, A., and Young, J.F. (2007b). Supplemental guanidino acetic acid affects energy metabolism of broilers. pp 339-342 in Proc. XVI Eur. Symp.On Poultry Nutrition, Strasbourg, France.

Lui, Z.; G. Wu; M.M. Bryant and D.A. Roland-Sr. (2005). Influence of added synthetic lysin in low-protein diets with the methionine plus cysteine to lysine ratio maintained at 0.75 J.A. Appl. Poult.Res. 14: 174-182.

Mitruka, B. M., and Rawnsley, H. M. (1977). Clinical biochemical and hematological reference values in normal experimental animals. Masson Publishing USA Inc..

Mousavi, S. N., Afsar, A., and Lotfollahian, H. (2013). Effects of guanidinoacetic acid supplementation to broiler diets with varying energy contents. Journal of Applied Poultry Research, 22: 47–54.

Oloruntola, O. D., Agbede, J. O., Ayodele, S. O., and Oloruntola, D. A. (2019). Neem, pawpaw and bamboo leaf meal dietary supplementation in broiler chickens: Effect on performance and health status. Journal of Food Biochemistry, 43(2), e12723.

Onu P.N.; M.C.A. Yo-Enwerm and E.O. Ahaotu (2010). Evaluation of carcass characteristics and costeffectiveness of broiler chicks fed synthetic lysine and methionine supplemented soybean-baseddiets. I.J.S.N. 1: 22-26.

Oyawoye, B. M., and Ogunkunle, H. N. (2004). Biochemical and haematological reference values in normal experimental animals. New York: Mason, 212-216.

Portocarero, N., and Braun, U. (2021). The physiological role of guanidinoacetic acid and its relationship with arginine in broiler chickens.Poult. Sci, 100, 101203.

Ringel, J., Lemme, A., amd Araujo, L.F. (2008). The effect of supplemental guanidine acetic acid in Brazilian type broiler diets at summer conditions. Poultry Sci. 87 (Suppl.1): 154.Sci. 88:205-212

Salem, H. B., and Smith, T. (2008). Feeding strategies to increase small ruminant production in dry environments. Small ruminant research, 77(2-3), 174-194.

Selim, Nessrin A.; Heba H. Habib; Hemat A.Abdel Mageed; Amany H. Waly; A.A. Fadl and S.M.Shalash (2016). Egypt. Poult. Sci. 36: 233-249

Stahl, C.A., Greenwood, M.W., and Berg, E.P., (2003). Growth parameters and carcass quality of broilers fed a corn-soybean diet supplemented with creatine monohydrate. Int. J. Poultry Sci. 2:404-408.

Tallentire, C. W., Leinonen, I., and Kyriazakis, I. (2018). Artificial selection for improved energy efficiency is reaching its limits in broiler chickens. Scientific reports, 8(1), 1-10.

Tossenberger, J., Rademacher, M., Németh, K., Halas, V., and Lemme, A. J. P. S. (2016). Digestibility and metabolism of dietary guanidino acetic acid fed to broilers. Poultry Science, 95(9), 2058-2067.

Vaughn, L., and Beckel, N. (2012). Severe burn injury, burn shock, and smoke inhalation injury in small animals. Part 1: burn classification and pathophysiology. Journal of Veterinary Emergency and Critical Care, 22(2), 179-186.

Wang, Y., Bryant, S. H., Cheng, T., Wang, J., Gindulyte, A., Shoemaker, B. A., ... and Zhang, J. (2017). Pubchem bioassay: 2017 update. Nucleic acids research, 45(D1), D955-D963.