The Effects of L-Arginine Supplement on the Growth Rate and Morphometric Performance of Three Indigenous Strains of Birds

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Abstract

This study investigated the effect of supplementary L-Arginine on the growth rate and morphometrics of three indigenous strains of chicken. A total of 297 12-week-old pullets comprising 99 Kuroiler, Sasso, and Shika Brown each. A 3x3 factorial trial was used and each treatment was replicated thrice. There were three levels of L-Arginine oral inclusion (0.00mg, 500mg, and 1000mg/3000ml of water) for each treatment and replicate respectively. Morphometric data measured were body weight (BW), back length (BL), breast girth (BG), comb height (CH), shank length (SL), thigh length (TL), wattle height (WH), wattle length (WaL), wing length (WL). The linear body measurements showed no significant (p>0.05) differences. However, birds administered with a higher (1000mg) dosage of arginine had nominally higher metric values compared to the other treatments. The Kuroiler had higher linear measures among the breeds. These were comparable to the Sasso but differed from the Shika which had the least linear body measures. Observed trends showed that the morphometric traits were higher for the interaction between 1000nmg arginine administration and Kuroiler than any other combinations. There were reversals and deviations from the above-reported trend in the Shika breed for BW, BG, and SL while other traits were similar.

Keywords: Amino acid; chicken; morphometric characteristics; productivity

1. Introduction

The poultry industry is a major and important industry that significantly contributes to meeting the food needs of the growing human population (Kumar *et al*., 2021). In various places, poultry has been a vital source of dietary protein to the teeming global population. In the animal husbandry subsector, the poultry business has been the fastest-growing and most dynamic (Adeniran *et al*., 2018).

In Nigeria, poultry production provides both social and economic benefits through food provision and revenue generation for farmers in many areas. In the rural areas, poultry provides employment and social benefits from the rearing of chicken and other poultry species to their supply chain (Shamsuddoha *et al*., 2015; Aswani *et al*., 2017). Specifically, indigenous chickens in Nigeria account for about 80% of the 185 million chickens and have contributed significantly to food security in the country (FAOSTAT, 2011; Alabi *et al*., 2020). Hence, the importance of adequate and proper nutrition in chickens cannot be overemphasized.

Over the years, the best amino acid levels in the poultry diet have been of huge commercial significance to the poultry enterprise. Ghoreyshi *et al*., (2019) indicated that methionine and lysine are the most limiting amino acids in the poultry diet. As a result, special attention is given to this amino acid while neglecting others such as arginine.

The role of arginine in poultry growth and reproductive performance cannot be overemphasized. Arginine is a potent secretagogue, increasing the amount of insulin and growth hormones that are released in the bloodstream. It also promotes ovulation by increasing the production of luteinizing hormone, which is important in oviposition and uterine contraction (Basiouni *et al*., 2006). For the synthesis of proteins, the intake of arginine from food is essential. They are also metabolically essential compounds like creatine in chickens. Thus, it is an indispensable amino acid in poultry with numerous physiological roles in reproduction, disease resistance, and growth (Alagawany *et al*., 2021; Hassan *et al*., 2021).

Furthermore, arginine acts as a stimulator of other amino acids such as creatine, proline, glutamine, and ornithine (Al-Daraji and Salih, 2012). It also stimulates compounds that play important roles in a chicken's physiological activities such as nitric oxides, polyamines, and dimethylargininesa (Fouad *et al*., 2012). Arginine supplementation in diets improves feed intake which results in increased feed conversion ratio and live body gain (Al-Daraji and Salih, 2012; Lieboldt *et al*., 2016). It also improves egg production and mass in local chickens (Silva *et al*., 2012; Youssef *et al*., 2015). Furthermore, arginine plays a vital role in disease resistance. According to Cengiz *et al*., (2010), supplementary arginine reduces proteinemia, and modifies the characteristics of erythrocyte, through reduced mean corpuscular hemoglobin load and increased mean volume.

Broilers have one of the highest arginine requirements due to their fast growth capacity and inability to synthesize. Dietary arginine may not be enough in some physiological or stressful conditions, resulting in poor weight gain and/or an inadequate antigen-specific immune response (Birmani *et al*., 2019). Tayade *et al*. (2006) demonstrated that arginine supplementation enhanced protection against infectious bursal disease viral challenge, indicating that this amino acid is favorable for immunological activities. Similar findings have been reported by Munir *et al* (2009) and Perez-Carbajal *et al*., (2010) for both for the humoral and the cellular immune response. It, therefore, becomes imperative to supplement arginine, in the poultry diet to meet their protein synthesis and other functional requirements.

Growth is a complex and dynamic physiological process that begins with the formation of the zygote and continues until adulthood. Bodyweight and morphometric measurements are key growth indicators in poultry production (Adeniji and Ayorinde, 1990). Furthermore, some morphological characteristics are linked to body weight (Ajayi *et al*., 2012). As a result, morphometric features could be employed as a marker in body weight loss programmes and as predictors of body weight.

The quantitative analysis of the size, shape, and structure of an organism is known as morphometric traits. The calculation of body weight using body measurements is a straightforward and practical procedure, particularly for rural poultry breeders with limited inputs (Semacula *et al*., 2011). Aside from being utilised as a marker of diverse body development, morphometric traits can also be used to construct breeding strategies by combining body measurements in the best possible way (Deribe *et al*., 2021) to attain maximal body weight and economic returns.

In Nigeria, work has been done extensively on methionine and lysine supplementation in poultry and monogastric production to investigate its effect on morphometric and growth performances. However, there is limited information on the effects of arginine on poultry. Hence, this study aims to determine the following objectives:

i. effect of arginine on growth performance and morphometrics of chicken strain
ii. effect of chicken strain on growth performance and morphometrics
iii. genetic influence of strain and arginine levels on growth performance and morphometric (interaction between strain and arginine levels)

2. Materials and Methods

2.1. Location of the experiment

The study will be conducted at Landmark University Teaching and Research Farm, Omu-Aran, Kwara State. The Teaching and Research Farm is located at latitude 8° 8’ 0” North and longitude 5° 6’ 0`` East, above sea level at the guinea savanna zone of Nigeria

2.2. Experimental birds and management

A total of 297 12-week-old pullets comprising 99 Sasso, Shika Brown, and Kuroiler strains respectively were used for the study. Before the commencement of the experiment, the birds were vaccinated and medicated following the normal routine vaccination and medication regime

2.3. Experimental design

A 3×3 factorial trial was used thus, giving rise to 9 treatments. Each treatment was replicated thrice. The treatments with Sasso, Shika brown, and Kuroiler strain had 11 birds each per replicate. There were three levels of L-Arginine oral inclusion (0.00mg, 500mg, and 1000mg/300ml of water) or (0.00mg, 167mg, and 333mg/litre of water respectively) for each treatment and replicate respectively.

2.4. Ethics Approval

The ethics for this research was approved by the Landmark University Ethics Research Ethics Review Committee.

2.5. Data collection

2.5.1. Growth Performance (kg)

The following morphometric data were measured using the measuring tape and measuring scale as described by Gueye *et al*., (1998) and Fayeye *et al*., (2006).

Bodyweight: Measured by placing each bird on the digital measuring scale and taking the readings.
Back length: length between the base of the neck and the uropygial(preen) gland.
Comb height: The distance between the point of the central spike and the comb's entrance into the skull. If there are an even number of spikes, the highest one must be chosen.
Comb Length: The distance between the comb's entry into the beak and the lobe's tip.
Breast girth: Tape-measured circumference of the breast area.
Wing length: The wing's length from the scapula joints to the final finger.
Wattle length: The wattle's second-largest dimension measured perpendicular to its length.
Shank length: Length of the tarsometatarsus from the hock joint to the metatarsal pad.
Thigh-length: the length from the shin bone femur joint to the shin-bone tarsus joint.

2.6. Data analysis

The Statistical Analysis System (SAS, 2002) was used to investigate the effects of oral inclusion and strain using the general linear model approach. The Turkey HSD multiple comparison tests were used to differentiate significant means (Turkey, 1953). The following model was used for the analysis of growth performance on morphometric measurements:

$$\mathbf{Y_{ijk}} + \mu + \mathbf{A_i} + \mathbf{S_j} + \mathbf{AS_{ij}} + \mathbf{e_{ijk}}$$

Where: $\mathbf{Y}_{ijk}$ = the observation
μ = overall mean
$\mathbf{A}_i$ = effect of the ith arginine inclusion level (i = 0, 4500g and 9000g/ replicate)
$\mathbf{S}_j$ = effect of the jth strain (j = Saso, Shika Brown and Kuroiler)
$\mathbf{AS}_{ik}$ = effect of interaction between arginine levels and chicken strain
$\mathbf{e}_{ijk}$ = random error

3. Results and discussion

3.1. Single effects of Arginine on morphometric measures

Table 1 shows the least square means (LSM) ± standard error of means, SEM, and LOS of morphometric measures for birds fed Arginine at 0, 500, and 1000mg respectively. There were no significant ($p>0.05$) impacts on linear body measurements due to the administration of arginine.
However, birds administered with a higher (1000mg) dosage of Arginine had nominally higher metric LSM values compared to the other treatments.

Table 1. Single effects of Arginine on morphometric measures

Arginine	0.00mg	500mg	1000mg	SEM	LOS
Body weight (kg)	1.98±0.06	1.96±0.06	2.04±0.06	0.17	NS
Comb length (cm)	4.56±031	4.27±0.31	4.08±0.31	0.92	NS
Comb height (cm)	1.96±0.21	1.80±0.21	2.39±0.21	0.62	NS
Breast girth (cm)	33.85±0.51	34.67±0.51	35.11±0.51	1.54	NS
Wing length (cm)	19.93±0.44	20.63±0.44	20.63±0.44	1.32	NS
Wattle length (cm)	3.46±0.17	3.46±0.17	3.39±0.17	0.50	NS
Wattle height (cm)	2.11±0.19	2.13±019	2.27±0.19	0.56	NS
Shank length (cm)	9.40±0.27	9.54±0.27	10.52±0.27	0.83	NS
Thigh length (cm)	4.01±0.64	14.09±0.64	16.22±0.64	1.92	NS
Back length (cm)	30.98±0.72	28.59±0.72	29.00±0.72	2.15	NS

NS: Not significant

3.2. Single effect of breeds on morphometric measures

Table 2 shows the least square means (LSM) ± standard error of means, SEM, and LOS of morphometric measures for birds of the different breeds used in the study. Highly significant ($p<0.01$; $p<0.0001$) differences in body linear measures were obtained for all traits except for shank length, body length, and thigh length. The Kuroiler had higher linear measures among all the breeds and these were comparable to the Sasso but differed from the Shika which had the least linear body measures.

Table 2. Single effect of Breeds on morphometric measures

Breeds	Shika brown	Kuroiler	Sasso	SEM	LOS
Body weight (kg)	$1.34^{b}\pm0.06$	$2.40^{a}\pm0.06$	$2.23^{a}\pm0.06$	0.17	***
Comb length (cm)	$3.41^{b}\pm0.31$	$5.26^{a}\pm0.31$	$4.24^{ab}\pm0.31$	0.92	**
Comb height (cm)	$1.36^{b}\pm0.21$	$2.92^{a}\pm0.21$	$1.86^{ab}\pm0.21$	0.62	***
Breast girth (cm)	$30.48^{b}\pm0.51$	$36.85^{a}\pm0.51$	$36.29^{a}\pm0.51$	1.54	***
Wing length (cm)	$18.56^{b}\pm0.44$	$22.17^{a}\pm0.44$	$20.46^{ab}\pm0.44$	1.32	***
Wattle length (cm)	$2.85^{b}\pm0.17$	$4.00^{a}\pm0.17$	$3.43^{ab}\pm0.17$	0.50	***
Wattle height (cm)	$1.43^{b}\pm0.19$	$3.02^{a}\pm0.19$	$2.06^{ab}\pm0.19$	0.56	***
Shank length (cm)	9.09±0.27	10.09±0.27	10.28±0.27	0.83	NS
Thigh length (cm)	13.26±0.64	15.39±0.64	15.68±0.64	1.92	NS
Body length (cm)	27.20±0.72	30.48±072	30.89±0.72	2.15	NS

[ab] means differ significantly ($p<0.01$;0.0001) across treatment levels.
NS: not significant

3.3 Interactive effect of Arginine and breeds on morphometric characters

Table 3 describes the results of the interaction between Arginine supplementation and breed type on chicken morphometrics. Except for wattle height, all other linear body measures differed significantly ($p<0.05$) across treatments.

Observed trends showed that body weight, comb height, breast girth, wattle length and height, shank length, and thigh length LSM were higher for the interaction between 1000mg Arginine administration and Kuroiler than any other combinations, nearly similar patterns were observed in the Sasso breed at the same level of Arginine administration. There were reversals and deviations from the above-reported trend in the Shika breed for body weight, breast girth, and shank length while other traits were similar. The interaction between 500mg and breeds showed a pattern that straddled the two extremes.

Table 3. Interactive effect of Arginine and breeds on morphometric characters

	0.00mg			500mg				
	Shika Brown	Kuroiler	Sasso	Shika Brown	Kuroiler	Sasso	Shika Brown	K
Body weight (kg)	1.42^{d}±0.10	2.29^{b}±0.10	2.23^{bc}±0.10	1.30^{d}±0.10	2.42^{ab}±0.10	2.17^{c}±0.10	1.31^{d}±0.10	2
Comb length (cm)	4.49^{ab}±0.53	5.39^{a}±0.53	3.81^{bc}±0.53	2.86^{c}±0.53	5.28^{a}±0.53	4.67^{a}±0.53	2.89^{c}±0.53	5
Comb height (cm)	1.89^{bc}±0.36	2.47^{b}±0.36	1.52^{c}±0.36	0.89^{c}±0.36	2.58^{b}±0.36	1.92^{b}±0.36	1.31^{c}±0.36	3
Breast girth (cm)	29.44^{d}±0.89	35.78^{b}±0.89	36.32^{b}±0.89	31.78^{c}±0.89	36.11^{b}±0.89	36.11^{b}±0.89	30.22^{cd}±0.89	3
Wing length (cm)	18.47^{b}±0.76	22.50^{a}±0.76	18.82^{b}±0.76	18.11^{b}±0.76	22.22^{a}±0.76	21.56^{a}±0.76	19.11^{b}±0.76	2
Wattle length (cm)	3.28^{b}±0.29	3.87^{ab}±0.29	3.22^{c}±0.29	2.61^{c}±0.29	4.03^{a}±0.29	3.67^{b}±0.29	2.67^{c}±0.29	4
Wattle height (cm)	1.78±0.32	2.90±0.32	1.66±0.32	1.06±0.32	3.08±0.32	2.27±0.32	1.44±0.32	3
Shank length (cm)	9.39^{c}±0.48	9.49^{b}±0.48	9.33^{c}±0.48	8.83^{c}±^{c}±0.48	10.11^{bc}±0.48	9.67^{c}±0.48	9.06^{c}±0.48	1
Thigh length (cm)	13.61^{bc}±1.11	14.89^{b}±1.11	13.53^{c}±1.11	12.22^{c}±1.11	15.50^{b}±1.11	14.56^{b}±1.11	13.94^{bc}±1.11	1
Back length (cm)	31.17^{a}±1.24	31.17^{a}±1.24	30.33^{a}±1.24	26.00^{c}±1.24	29.11^{b}±1.24	30.67^{a}±1.24	24.44^{c}±1.24	3

^{abcd} means differ significantly ($p<0.05$) across treatment levels. NS: not significant

The overall importance of Arginine in avian biology has been reported, but the apparent lack of significant ($p<0.05$) impact of Arginine as a single factor in the study contrasted with the claims that Arginine supplementation in the diet significantly improves feed intake, feed conversion ratio, and live body weight gain (Al-Daraji and Salih, 2012; Leiboldt *et al*., 2015). The observation may be due to the route of administration which in this study was by the drinking water which further limits the quantity of Arginine that is supplied. However, the observed nominal trend of higher morphometric measures with an increased dose of Arginine observed supported the trend of higher increased growth in broiler laying hens and their progeny as reported by Fernandes *et al*., (2014). It is, therefore, possible to hypothesize that a higher dosage or more direct route of dietary supplementation might have a more profound influence as evidenced by the claim that several factors. Such factors include protein synthesis and degradation rates, metabolic compound synthesis, and the utilization of arginine to synthesize urea (Ball *et al*., 2007; Zampiga *et al*., 2018; Ghoreyshi *et al*., 2019), as well as increasing age and enhancing feather coverage as a result of the high arginine content in feathers (Bequtte, 2003) which raises the arginine requirement above NRC recommended levels. Arginine also causes the production of somatotropin and insulin-like growth factor. Mitogenesis is then induced by GH and GF, resulting in lengthy bone development (Isaksson *et al*., 1987 cited in Fernandes *et al*., 2014). Additionally, various anabolic effects in skeletal muscle metabolisms, such as satellite cell differentiation and proliferation are also related to arginine (Florini *et al*., 1996, cited in Fernandes *et al*., 2014), and myofibrillar protein aggregation.

The observed significant ($p<0.01$; 0.0001) differences due to the single effect of breed on linear body measurements obtained in this study were similar to the comparison made by Olawunmi *et al*., (2008) between the Yoruba and Fulani ecotype of indigenous chickens of Nigeria. This may suggest a departure in function between genotypes. Observed body length measures for the Kuroiler and Sasso breed were similar to the length of 30.10 cm reported by this author for the Fulani ecotype. Olawunmi *et al*., (2008) also stated that body length together with head length confers superiority for egg-laying potential on a particular breed of chicken. Breast girth which is a measure of meatiness in birds was higher than the values (12.12-14.05) reported by Fayeye *et al*., (2014) for Isa brown and Ilorin ecotype chickens. Maciejowski and Zeiba (1982) cited in Fayeye *et al*., (2014) reported that leg development was indicated by morphometric features such as shank length and diameter, while breast development was indicated by body girth. Aside from being utilised as a bodyweight indicator, morphometric features can also be used to design breeding strategies by combining body measurements in the best possible way (Deribe *et al*., 2021) to attain maximum body weight, and egg weight, and economic returns. The interaction between Arginine and breeds and its significant ($p<0.05$) impact on measured morphometric traits in all breeds supports the position that several factors interact together to influence and determine Arginine requirements in chicken (Zhang *et al*., 2017; Lambert and Corrrent, 2018). This study shows that Kuroiler and Sasso perform better at higher Arginine dosage compared to the Shika brown breed whose higher body weight and body length were at 0.00mg Arginine supplementation.

The high requirement for arginine by the Kuroiler and Sasso breeds which were heavier than the Shika brown may be because they require more due to the stress of the local environment compared to the Shika brown to maintain productivity and supports the claim that selection for high production efficiency in layers caused highly adapted lines or genotypes, which were less capable to cope with environmental stress compared to low production efficiency genotypes (Boettcher *et al*., 2013) since Arginine has been implicated in poultry stress management system. The impact of interaction on shank length also follows the pattern discussed above for body weight and back length and may be related to the function of Arginine in muscle development (Farnandes *et al*., 2014).

4. Conclusion

At the end of this study, it was inferred that higher levels of Arginine supplementation were useful for the Kuroiler and Sasso breeds but not necessarily for the Shika Brown breed. Also, distinct differences in breed morphometric measures obtained showed that morphometric traits can be used in selection and breeding. The effect of the interaction between Arginine levels and breeds shows that response to Arginine supplementation by the breeds' impact genetic parameters and higher proficiency layers respond better to higher Arginine supplementation. It is therefore recommended that further studies using higher and lower levels of Arginine supplementation in the drinking water of Sasso, Shika brown, and Kuroiler birds, to determine its effects on morphometrics and growth performance should be carried out.

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