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Effect of Vitamin C Supplementation on Egg Quality, Carcass Characteristics and Sensory Properties of Meat of the Pearl Guinea Fowl *(Numida meleagris*) in Ghana

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Authors' contributions

This work was carried out in collaboration among all authors. Authors PAPJ, OK and HS designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors CGK, GT and PAPS performed the statistical analysis, managed the analyses of the study and managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The objective of the experiment was to investigate the effect of vitamin C supplementation on egg quality, carcass characteristics and meat sensory properties of the Pearl Guinea fowl (*Numida meleagris*) in Ghana. Three hundred and sixty day old keets of the Pearl breed of Guinea fowl were used under a completely randomized design divided into four groups (CTL (control), Vit C 10, Vit C 20 and Vit C 30) each with 3 replications of 30 keets. The experimental birds were supplemented with Vitamin C dissolved in drinking water at a dose of 0, 10, 20 and 30 mg/bird/day for groups CTL

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(control), Vit C 10, Vit C 20 and Vit C 30 respectively. Data collected were subjected to analysis of variance with the aid of GenStat version 11.1. The result showed that egg weight, albumin weight and yolk height significantly (P=.05) increased with increasing levels of vitamin C. Haugh unit (egg quality) improved (P=.05) with increasing levels of vitamin C. Birds supplemented with 30 mg/bird/day of vitamin C had the highest (P=.05) live body weight, defeathered weight, thigh weight, wing weight and liver weight while the control treatment recorded the least in all traits. Empty gizzard weight was significantly (P=.05) higher among birds on the control treatment. Birds supplemented with 30 mg/bird/day of vitamin C significantly (P=.05) had the best aroma, colour and flavour. This study concludes that egg quality, carcass quality and sensory attributes of Guinea fowl meat improved with increasing levels of Vitamin C. This study recommends to farmers that Vitamin C supplements up to 30 mg/bird/day is an ideal level to improved egg and meat quality, meat sensory attributes of indigenous Guinea fowls.

Keywords: Heat stress; vitamin C; primal cuts; giblets; sensory attributes.

1. INTRODUCTION

Guinea fowl is one of the most common poultry species found in the northern regions of Ghana [1]. The bird plays an important role in the social life of many tribes in Ghana [2]. This is because the meat of Guinea fowl is highly accepted for food locally with no restriction or religious taboos [1,2]. The bird is highly prized in many socio-cultural functions such as dowry and festivities. Despite the high demand for meat and eggs among consumers, the productivity of the bird is very low as compared to broilers and local chickens due to the small sizes of the egg, keets mortalities, nutrition, seasonal variation and heat stress [2,3].

In Guinea fowl production, heat stress has caused economic loss and concurrent welfare issues [2,3]. The best way to avoid heat stress is maintaining the right ambient temperature. The deleterious effects of high environmental temperature on Guinea fowl production have been well documented. Body weight gain, growth rate, feed consumption and feed efficiency were significantly lowered by subjecting chicks to heat stress [4]. Seasonal heat stress negatively influences the performance of Guinea fowls [1,5].

Guinea fowls are exposed to different environmental conditions which affect reproductive, growth and laying performance, egg and meat quality. Although, the birds are able to synthesis vitamin C, but this synthesis is thought to be inadequate during times of heat stress, disease and intensive production. In the northern parts of Ghana where Guinea fowl production is very intensive, temperatures are very high; hence, the birds are subjected to considerable heat stress and diseases which affect productivity as well as meat quality. Vitamin C, also known as L-ascorbic acid, is a water-soluble vitamin that is naturally present in some foods, added to others, and available as a dietary supplement is one of the nutritional factors important for poultry performance and meat quality [6]. In poultry production, it is required to maintain normal body metabolic activities and to meet physiological requirements [7].

Vitamin C plays an important role in the biosynthesis of corticosterone which is a hormone that enhances energy supply during stress [7,8]. According to Kassim and Norziha [8] dietary inclusion of vitamin C has some beneficial effects in preventing adverse effects of heat stress, disease and increase productivity in birds. Research has shown that, supplementation of vitamin C either in diets and or in drinking water significantly reduces the negative effect of heat stress, increase egg and meat quality and improved disease resistance of the birds [9,10]. The ultimate goal of the study was to reduce the negative effect of heat stress to improve the quality of Guinea fowl eggs and meat.

The objective of this study was to investigate the influence of Vitamin C supplementation on egg quality, carcass characteristics and sensory analysis of indigenous Guinea fowl (*Numida meleagris*) in Ghana.

2. MATERIALS AND METHODS

2.1 Experimental Area

The experiment was carried out at the Poultry Section of the Animal farm of the Department of Animal Science Education, University of Education, Winneba, Mampong-Ashanti, Ghana. Mampong-Ashanti lies in the transitional zone

between the Guinea savanna zone of the north and the tropical rain forest of the south of Ghana along the Kumasi-Ejura road. Mampong lies on latitude 07˚03' N and longitude 01˚24'W on an altitude of 289.7 m above sea level. The rainfall pattern is bimodal, with the major rainfall season occurring from April to July with 1000 mm of rainfall while the minor season occurs from August to November with 350 mm of rainfall [11].

2.2 Experimental Design and Treatments

Three hundred and sixty (360) day old keets of the Pearl breed of Guinea fowl were used under a completely randomized design (CRD) divided into four treatments groups (A, B, C and D) each with 3 replications of 30 keets, which gave a total of twelve replications.

2.3 Management and Feeding of Experimental Birds

The keets were reared under similar managerial conditions. Keets in each group were fed a balanced diet *ad libitum*. Day old keets were fed with a starter ration from day 1 up to 6 weeks of age. Grower diets were given from 6 weeks of age up to 12 weeks of age. The finisher diets were given from 12 weeks of age up to 24 weeks of age. The starter ration contained 22% crude protein and 2,950 kcal ME/kg diet. The grower ration contained 17.5% crude protein and 2,800 kcal ME/kg diet (Table 1). The finisher ration contained 16% crude protein and 2,800 kcal ME/kg diet according Annor et al. [12] (Table 1). The experimental birds were supplemented with Vitamin C dissolved in drinking water at a dose of 0, 10, 20 and 30 mg/bird/day for groups A CTL (control), VitC10, VitC20 and VitC30 respectively. Vaccination and other routine poultry practices were also carried out.

2.4 Egg Quality Traits

2.4.1 External egg quality traits

The birds started laying at twenty weeks of age. At twenty-four weeks of age, eggs were collected in the morning at 9:00 am and stored at an ambient temperature of 30ºC and relative humidity of 70%. The eggs were stored for five hours before egg quality assessment was carried out. A total of thirty- six (36) eggs were used for the assessment. Nine eggs from each treatment. External egg quality traits measured included; egg weight, shell weight and shell thickness. The weight of the eggs was weighed using electronic balance and recorded in grammes (g). The shells were cleaned, washed and air-dried at room temperature (28ºC) until a constant weight was obtained using electronic balance and recorded in grammes (g). Shell thickness were determined from the broad end, narrow end and the middle of the shell using micrometer screw gauge and the average of the three measurements was taken as shell thickness in millimeters.

2.4.2 Internal egg quality traits

Internal egg quality traits measured included; albumen height, albumen weight, yolk weight, yolk height, colour and haugh unit. The above mentioned internal qualities were determined by cracking and breaking gently each egg into a clean petri dish and measurements were taken with the aid of a venier caliper sensitive to 0.01 mm. The yolk and albumen were carefully separated and weighed using the electronic weighing scale. The colour of the yolk was measured using the Roach colour fun measurement, which consists of 1-15 strips ranging from pale to orange yellow in colour [13] and the higher the value the yellower the yolk. Haugh unit measures the quality of the egg and it was calculated using the following formula adopted from Haugh [14].

$$HU = 100 \log (H - 1.7w^{0.37} + 7.6)$$

Where,

HU = Haugh Unit
H =Albumen height (mm)
W= Egg weight (g)

2.5 Carcass Characteristics

A total of sixteen birds aged twenty-four weeks were randomly selected and used for the carcass analysis. Four birds from each treatment. Each bird was weighed (live weight) using electronic balance and recorded in grammes (g) after a 24-hour feed withdrawal, and tagged to differentiate them. The birds were then stuck with a sharp knife to cut the jugular veins and were allowed to bleed for approximately 60 seconds, after which they were scalded in warm water (60ºC). The feathers were plucked manually and head and shanks removed. Re-weighing of carcass after evisceration to obtain carcass weight was done. An incision was then made around the vent to remove the viscera. The viscera were separated into intestines, gizzard, liver and spleen. All the primal and giblets parts were cut and weighed using electronic balance and recorded in grammes (g).

2.6 Sensory Evaluation of Carcass

The breast and thigh meat were used for sensory evaluations. A total of twelve (12) panelists aged between 24-40 years from the University of Education, Winneba, Mampong-Ashanti campus, consisting of six females and six males were randomly selected and trained according to the British Standard Institution guidelines to evaluate poultry meat quality [15]. Seven parameters were taken into consideration which included: acceptance, aroma, colour, flavour, juiciness, tenderness and texture. The breast muscles of the meat were cooked for 40 minutes after a core temperature of 100ºC using a gas stove. The meat samples from the various treatments were sliced into uniform sizes and cooked in equal quantity of water (600 ml) and salt (3 g) and presented to the panelists. Each of the treatment samples were replicated three times, making a total of twelve samples. Each panelist was provided with water and pieces of bread to serve as neutralizers between the products. A five-point category scale was used to evaluate the sensory characteristics of the Guinea fowl meat as follows: Acceptance; Dislike very much (1), Dislike (2), intermediate (3), Like (4), like very much (5).Aroma: Very weak (1), weak (2), intermediate (3), strong (4), very strong (5); Colour: Very pale red (1), Pale red (2), Intermediate (3), Dark red (4), very dark red (5); Guinea fowl flavour: Very weak (1), weak (2), moderate (3), strong (4), very strong (5); Juiciness: Very dry (1), dry (2), intermediate (3), juicy (4), very juicy (5); Tenderness: Very tough (1), tough (2), intermediate (3), tender (4), very tender (5); Texture: Dislike very much (1), Dislike (2), intermediate (3), Like (4), Like very much (5).

2.7 Statistical Analysis

The data collected were analyzed using the one-way analysis of variance (ANOVA) with the aid of GENSTAT Version 11.1 (2008) according to previously described [16,17] and the treatment means were separated by the least significant difference (LSD) to determine which of the treatments has significant difference or not at 5% probability level.

3. RESULTS AND DISCUSSION

3.1 Effect of Vitamin C Supplementation on Egg Quality Traits

There were significant (P=.05) differences observed in egg weight, albumen height, albumen weight, yolk height and haugh units across the treatment groups. However, shell weight, thickness, yolk weight and yolk colour were not significantly (P=.05) affected. The results presented in Table 2 shows that birds supplemented with 30 mg/bird/day of vitamin C recorded the highest egg weight followed by birds supplemented with 10 and 20 mg / bird / day of vitamin C with the control being the least. The improved egg weight observed among the treatment groups as compared to the control can be explained that vitamin C is associated with the conversion of body proteins and fat into energy for growth and survival through increased corticosterone secretion which significantly enhanced egg weight [18,19]. According to [19] addition of vitamin C in drinking water enhance digestibility, resulting in increasing average daily gain and body weight, which significantly enhanced egg weight. In an experiment conducted by Lohakare et al. [20] and Lu et al. [21] it was reported that high temperature condition decreased the true digestibility of protein, which might deter the activity of protein digestive enzymes (trypsin, chymotrypsin, and amylase) under heat stress which affect body weight and laying performance. However, in this study, these negative influences on digestibility were moderated through the supplementation of vitamin C in drinking water.

Albumin height was highest (P=.05) among eggs collected from birds supplemented with 30 mg/bird/day of vitamin C while the lowest albumin height was recorded from the control treatment and 10 mg/bird/day of vitamin C with similar mean values. Birds supplemented with 30 mg/bird/day of vitamin C recorded the highest (P=.05) albumin weight and yolk height while the control treatment recorded the least (P=.05) albumin weight and yolk height. The result from Table 2 shows that Guinea fowl egg quality increased with increasing levels of vitamin C. Birds supplemented with 30 mg/bird/day of vitamin C recorded the highest haugh unit value followed by birds supplemented with 20 and 10 mg/bird/day of vitamin C with the control being the least.

Albumin height, weight and yolk height increased with increasing levels of vitamin C in drinking water. This could be attributed to the improved egg weight observed in this study. Increase in egg weight result in an increased in albumin weight and height, yolk weight and height. According to Imik et al. [22] and Halıcı et al. [23] the combination of 200 mg vitamin C and 250 mg vitamin E improved nutrient digestibility of dry

matter, organic matter, crude protein, and ether extract in Japanese quails which improves egg quality traits. Nevertheless, this study did not investigate the digestibility of feed being fed to the birds. The study could anticipate that supplementation of vitamin C increased the digestive capacity under heat stress, which resulted in a significant change in albumin height, weight and yolk height. The significant differences observed indicate that albumin height, weight and yolk height are directly proportional to vitamin C levels in the drinking water suggesting that the physiological processes occurring during egg formation are significantly affected by the inclusion of vitamin C [24,25].

3.2 Effect of Vitamin C Supplementation on Carcass Characteristics

Table 3 shows that birds supplemented with 30 mg/bird/day of vitamin C had the highest (P=.05) live body weight, defeathered weight, thigh weight, wing weight and liver weight while the control treatment recorded the least in all traits. Empty gizzard weight was significantly (P=.05) higher among birds on the control treatment followed by birds supplemented with 10 mg/bird/day of vitamin C. However, birds supplemented with 20 and 30 mg/bird/day of vitamin C recorded the least empty gizzard weight. The detrimental influences in Guinea fowl production by heat stress were found not only in their egg quality, but also meat quality. Heat stress induced alterations of muscle metabolism and membrane integrity, which could be associated with the meat quality [26,27].

Guinea fowls that drank liquid vitamin C might have electron donors to neutralize free radicals to improve meat quality, which is in agreement with results of a previous study conducted by [26,28]. According to Taweli et al. [25] and Vathana [26] the supplementation of Vitamin C prevented lipid oxidation in chicken meat which affect quality is a consequence of oxidant stress. The findings in this study showed that defeathered weight, thigh weight, wing weight and liver weight meat samples from the Guinea fowls that drank the water supplemented with vitamin C had higher values than the control group, suggesting that vitamin C might improve lipid stability and reduce lipid oxidation to improve meat quality. Similarly, some studies suggested that vitamin C supplementation increased thigh weight, wing weight and liver weight and decreased empty gizzard weight [22,24,28].

3.3 Effect of Vitamin C Supplementation on Sensory Evaluation

Different levels of vitamin C supplementation had significant (P=.05) effect on colour and flavour of meat from breast and thigh. However, all other traits were found not significant (Table 4).Birds supplemented with 30 mg/bird/day of vitamin C significantly (P=.05) had the best aroma followed by 20 and 10 mg/bird/day of vitamin C, while the control treatment recorded the poorest aroma. Birds supplemented with 30 and 20 mg/bird/day of vitamin C had a fine colour followed by 10 mg/bird/day of vitamin C while the control treatment recorded the least. Guinea fowl meat flavor was significantly (P=.05) better among birds supplemented with 30 mg/bird/day of vitamin C followed by 20 and 10 mg/bird/day of vitamin C, while the control treatment recorded the average.

Table 1. Percentage composition of the experimental diet

Ingredients	Starter diet (kg)	Grower diet (kg)	Breeder diet (kg)
Maize	57.5	58.0	53.0
Wheat bran	11.0	21.0	20.0
Soya bean meal	8.50	5.00	8.00
Tuna fish meal	11.0	6.00	7.00
Russia fish meal	9.00	7.00	3.00
Oyster shells	1.50	1.50	7.5
Calcium	0.50	0.50	0.50
Vitamin premix	0.50	0.50	0.50
Salt	0.50	0.50	0.50
Crude protein (%)	22.0	17.5	16.5
Total	**100**	**100**	**100**

Table 2. Effect of different levels of vitamin C supplementation on egg quality traits

Parameters	Control	Vitamin C (mg/bird/day)			SEM	*P*
	0	10	20	30		
External egg quality traits						
Egg weight (g)	40.0^{d}	43.0^{b}	42.5^{c}	44.3^{a}	0.35	0.02
Shell weight (g)	8.00	7.75	7.44	7.50	0.45	0.09
Shell thickness (mm)	0.74	0.76	0.76	0.77	0.05	0.11
Internal egg quality traits						
Albumen height (cm)	2.77^{b}	2.77^{b}	2.85^{b}	3.13^{a}	0.21	0.01
Albumen weight (g)	18.0^{c}	20.5^{b}	20.4^{b}	21.5^{a}	0.26	0.01
Yolk height (cm)	1.29^{c}	1.95^{b}	2.11^{ab}	2.35^{a}	0.30	0.03
Yolk weight (g)	14.8	14.8	14.7	15.3	0.37	0.08
Yolk colour	7.50	7.25	7.85	7.50	0.59	0.15
Haugh unit	48.5^{d}	54.8^{c}	56.1^{b}	58.1^{a}	0.15	0.01

^{abcd} *Means bearing different superscripts in the same row are different at p<0.05, Values are means of three replicates, SEM= standard error of means, p = probability of main effects*

Table 3. Effect of different levels of vitamin C supplementation on carcass characteristics

Parameters	Control	Vitamin C (mg/bird/day)			SEM	*P*
	0	10	20	30		
Live body weight (g)	1453^{c}	1498^{b}	1567^{a}	1588^{a}	25.3	0.01
Bled weight (g)	1285	1289	1297	1311	29.5	0.33
Defeathered weight (g)	1184^{c}	1194^{c}	1203^{b}	1217^{a}	9.55	0.04
Dressed weight (g)	1089	1095	1106	1109	20.5	0.53
Dressing %	73.5	72.8	74.8	73.9	5.31	0.28
Primal cuts						
Breast weight (g)	259	253	267	262	8.93	0.11
Drumstick weight (g)	53.7	52.8	53.2	54.9	5.11	0.22
Head weight (g)	36.9	35.7	36.5	37.8	4.51	0.23
Neck weight (g)	58.9	59.3	57.5	60.3	4.93	0.41
Shank weight (g)	13.5	12.8	14.2	14.5	3.52	0.09
Thigh weight (g)	66.5^{c}	74.2^{b}	75.3^{b}	82.2^{a}	6.11	0.03
Wing weight (g)	58.3^{c}	65.8^{b}	66.4^{b}	70.8^{a}	3.87	0.04
Giblets traits						
Crop weight (g)	11.5	9.32	10.6	8.97	4.71	0.09
Empty gizzard weight (g)	29.6^{a}	22.3^{b}	20.5^{c}	20.2^{c}	2.01	0.03
Heart weight (g)	7.89	7.55	7.93	7.48	3.61	0.25
Intestine weight (g)	38.3	38.9	38.2	37.8	2.91	0.37
Liver weight (g)	16.4^{d}	17.5^{c}	18.3^{b}	18.9^{a}	3.44	0.02

^{abcd} *Means bearing different superscripts in the same row are different at p<0.05, Values are means of three replicates, SEM= standard error of means, p = probability of main effects*

Table 4. Effect of different levels of vitamin C supplementation on sensory attributes

Parameters	Control	Vitamin C (mg/bird/day)			SEM	*P*
	0	10	20	30		
Acceptance	7.54	7.20	7.94	7.31	0.64	0.35
Aroma	1.96^{d}	2.17^{c}	2.55^{b}	2.97^{a}	0.18	0.01
Colour	2.40^{c}	3.26^{b}	3.87^{a}	3.95^{a}	0.54	0.02
Flavour	2.11^{c}	3.49^{b}	3.68^{b}	4.20^{a}	0.33	0.01
Juiciness	3.11	3.59	3.22	3.71	0.49	0.11
Tenderness	3.88	3.60	3.59	3.76	0.71	0.14
Texture	6.67	6.53	7.22	6.60	0.52	0.15

^{abcd} *Means bearing different superscripts in the same row are different at p<0.05, Values are means of three replicates, SEM= standard error of means, p = probability of main effects*

Aroma, colour and flavor were linearly changed due to the inclusion of vitamin C in drinking water. The improvement in aroma, colour and flavor observed among the treatment groups as compared to the control can be explained that vitamin C supplementation minimizes the oxidative stress associated with the respiratory burst of activated phagocytic leukocytes, thereby functioning to control the inflammation and tissue damage associated with immune responses [24,28]. Similar findings were reported by Imik et al. [22] and Halıcı et al. [23] who reported that ascorbic acid supplementation positively affected meat colour and caused an increase in aroma and flavour values in broilers. According to [22,24,27] dietary ascorbic acid supplementation significantly affects colour and aroma of broiler meat but not flavor and texture.

4. CONCLUSION

This study concludes that Guinea fowl egg quality improved with increasing levels of vitamin C. Vitamin C supplements up to 30 mg/bird/day improved carcass quality and sensory attributes of Guinea fowl meat. Guinea fowls that drink water supplemented vitamin C have positive results in egg and meat quality. Consequently, Guinea fowls are expected to become less susceptible to heat stress by drinking water supplemented with Vitamin C. This study recommends to farmers that Vitamin C supplements up to 30 mg/bird/day is an ideal level to improved egg and meat quality, sensory attributes of indigenous Guinea fowls.

ETHICAL APPROVAL

As per international standard guideline written ethical approval has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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