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Effects of vitamin c and zinc supplementation in drinking water on growth performance of broiler chickens reared in the tropics

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Target Audience: *Animal scientists, Poultry farmers, Physiologists, Meat processors*

Abstract

This study was conducted to determine the effects of dietary supplemental vitamin C and zinc on performance and carcass characteristics of broiler chickens reared under tropical condition. A total of 120 one-day-old mixed sex Abor acre chicks were assigned based on body weight to four dietary treatments. There were three replicate pens for each treatment and 10 broilers per replicate pen. The control group (T1) received no additive; while chicks in T2, T3 and T4 had 120g vitamin C with 40mg Zinc, 240g Vitamin C with 80mg Zinc and 360g of Vitamin C with 120mg Zinc in 1000L of water, respectively. Chicks were fed the same diet based on a 2-phase feeding program i.e. starter and finisher phases. Feed and water were given on ad libitum basis. Data collected were analysed using GLM procedure of SAS 2001. At the starter phase dietary treatments had significant (P < 0.05) effects of weight gain, average daily weight gain, feed conversion ratio (FCR) and water intake. Chicks administered 240g Vitamin C with 80mg Zinc had the best results in terms of weight gain and feed conversion ratio. However, at the finisher phase dietary treatments had significant (P < 0.05) effect on the water intake only. Improved carcass characteristic was observed in broiler chickens given vitamin C and zinc supplements. Based on the improved FCR, it was concluded that the administration of 240g Vitamin C with 80mg Zinc in drinking water of broiler chicks has the potential to enhance growth performance without any adverse effect.

Keywords: *Vitamin C, zinc, broiler, performance, carcass quality*

Description of Problem

Commercial poultry enterprise currently still remains one of the fastest growing animal enterprises due to higher nutritional efficiency and fast growth characteristics which might be due to genetic selection and nutritional strategies aimed at pushing the meat broilers to grow faster. However, these have exerted these broilers to nutrient requirement manipulations, physiological stresses and pathological states of potential welfare concerns (1). In most tropical countries, where average temperature can be as high as 40^{o}C, heat stress is a potential threat to the fast-growing broiler chickens which could cause under performance, suppressed feed intake, suppressed immunity and high mortality in meat type chicken (2). Vitamins and minerals are the foundation of balanced animal nutrition. They are essential, irreplaceable micronutrients that are required for normal physiological functions including growth, body development and reproduction, as well as animal well-being and general health status. Furthermore, conventional feed supplemented with vitamin and mineral additives may be used to reduce the effect of heat stress on broiler performance. Most vitamins and minerals cannot be synthesized

by animals and must be obtained by feed; however, feed alone is not enough to ensure the right vitamin status. This is due to multiple factors such as: low and/or variable vitamin levels, limited bioavailability, storage conditions and treatments applied to feedstuffs during feed manufacturing.

The combination of minerals and vitamins supplementation is very effective in ameliorating heat stress in broiler production. Vitamin C and selenium (Se) possess anti-oxidative properties and help in improving immune response of broilers. Similarly, vitamin E and selenium (Se) have synergistic effects in reducing heat stress (3). Zinc (Zn) plays a crucial role in enhancing immune function and maintaining cell integrity by avoiding oxidative damage (4) and its requirements increases in high ambient temperature (5). Synthesis of vitamin C is inadequate in young chicks and in stressed birds. Vitamin C supplementation leads to strengthening of the antioxidative defence mechanism and, as a consequent, minimize oxidative stress (6). Zinc is used in poultry diets because of its anti-stress effects and plays a crucial role in enhancing immune function and maintaining cell integrity by avoiding oxidative damage (5). Moreover, it is evident from different research works that the requirement of Zn is increased and its retention decreases during stress and this indicates the importance of supplementation of Zn during stress (7,8).

Dietary inaccessibility and loss of minerals - vitamins in commercial poultry feeds could be due to the use of adulterated feed stuff, expired feed stuff and poor storage. Therefore, direct presentation of nutrients through water medium could be used to reduce the effect of the nutrients lost in feed. Monitoring the water consumption on a daily basis has shown to be a measure of broiler performance. This study was initiated to proffer solutions to the outcry of small to medium scale poultry farmers using commercial broiler feeds in Kogi state but still having issues with high mortality and poor growth performance of broiler chickens as result of heat stress. Therefore, the aim of this study was to determine the growth performance, water consumption and carcass characteristics in broilers by combined feed supplementation of minerals and vitamins through water medium.

Materials and Methods

Bird Husbandry and Dietary Treatments

The experiment was carried out at the poultry section at College of Agriculture, Kabba, Ahmadu Bello University. A total of 120 one-day-old mixed sex Abor Acre broiler chicks from a reputable commercial hatchery were used in this experiment. Birds were randomly allocated based on approximately equal weight to 12 identical pens with 10 birds each in completely randomised design. Non-reused wood shavings were used as litter. Pens were assigned to 4 treatments: control group (T1), 120g Vitamin C with 40mg of Zinc (T2), 240g Vitamin C with 80mg of Zinc (T3) and 360g of Vitamin C with 120mg of Zinc (T4) in 1000L of water, respectively. Water treatments were prepared daily at 07:00 h in a clean basin per treatment. Water consumption was recorded daily per treatment. Sixteen hours light was made available to the chickens throughout the experiment periods. Temperature and environmental humidity were recorded continuously. All birds were reared in an environmentally controlled house and had unlimited access to a commercial feed and water throughout the duration (49 days) of the experiment. The proximate analysis of the commercial feed used is shown in Table 1. Birds were vaccinated against Newcastle, Infectious Bronchitis and Infectious Bursal diseases. Birds were fed commercial diets

both at starter and finisher phases. Feed and water were given *ad libitum*.

Data Collection and Sampling

Feed and water Intake: The commercial crumble feed was given to all the experimental birds. Feed and water offered on daily basis and leftover was recorded in morning and evening on daily basis.

Body weight gain: Birds were initially weighed on the first day and then at the end of every week to determine total body weight gain.

Feed Conversion Ratio (FCR): From the primary data collected for feed intake and weight gain, other data for feed conversion rate and feed cost per unit gain in weight were generated. i.e. FCR = Total feed consumed / Total weight gain.

Mortality: Mortality record was recorded as it occurred.

Carcass characteristics: Three birds per replicate with weights closest to the mean body weight of the replicate were used for the carcass study. The birds were slaughtered after being starved for twenty-four hours. The birds were weighed, slaughtered, de-feathered and eviscerated. Weights of the primal cuts, the giblets and the abdominal fat were taken and expressed as percent of the dressed weight.

Table 1: Proximate analysis of commercial broiler starter and finisher diets

	Starter	Finisher
Crude protein (%)	23.00	20.00
Metabolizable Energy Kcal/Kg	3050	2970
Crude fibre (%)	3.00	3.20
Calcium	1.30	1.30
Fat (%)	5.50	6.00
Available Phosphorus (%)	0.52	0.45
Methionine (%)	0.57	0.55
Lysine (%)	1.32	1.21

Table 2: Performance of Broiler chicks as Influenced by Vitamin C and Zinc Supplementation (0- 4 Weeks)

	Vitamin C and Zinc				
Parameters	T1	T2	T3	T4	SEM
Initial weight (g)	39.01	39.00	39.00	39.00	0.01
Final weight(g)	1000.36^{c}	1165.33^{a}	1184.33^{a}	1116.29^{b}	12.85
Weight Gain (g)	961.32^{c}	1126.33^{a}	1145.33^{a}	1077.28^{b}	12.85
Av. daily gain (g)	34.33^{c}	40.23^{a}	40.90^{a}	38.47^{b}	0.41
Total Feed Intake (g)	1941.00	1934.50	1942.43	1911.00	18.09
Daily Feed Intake (g/b/d)	69.32	69.09	69.37	68.25	0.64
FCR	2.02^{c}	1.72^{b}	1.70^{a}	1.77^{b}	0.03
Water (litre)	2708.33^{b}	2930.00^{a}	2870.00^{a}	2890.00^{a}	39.31
Mortality (%)	3.70	3.75	3.55	3.50	0.80

a, b, c = Means with different superscript on the same row differ significantly ($P<0.05$)
SEM = Standard Error of Means
FCR = Feed conversion ratio

Statistical Analyses:

All data obtained were statistically analysed using the General Linear Models (GLM) procedure of (9) for the analysis of variance. Duncan's multiple range test was used to determine differences among treatment means (10) at 5% significance level (P=0.05). The growth response estimates of broiler chickens to varying levels of vitamin C and Zinc was determined by regression analysis.

General Linear Model

$Y_{ij} = \mu + K_{i+} e_{ij}$

Y_{ij}= Observation of the i^{th} level of vitamin C and Zinc and as shown by broilers performance

μ= Overall mean

K_i =i^{th} effect of vitamin C and Zinc

e_{ij} = Random error

Results and Discussion

The nutrient analysis for the starter and finisher commercial diets used in this study is shown in Table 1. All the values obtained were similar or slightly above the broiler chicken recommendations of (11). The effects of dietary supplemental Zinc (Zn) and vitamin C on performance parameters of broiler starter chicks (0-4 weeks) is shown in Table 2. Inclusion of vitamin C and zinc in water had significant ($p<0.05$) effects on body weight, feed conversion ratio and water consumption. Broiler chicks given supplemental vitamin C and zinc had better results in terms of body weight, feed conversion ratio and water consumption compared to those given non-supplemented water. A linear increase as the levels of vitamin C and Zn increased was observed for final weight and weight gain but began to reduce at 360g of vitamin C with 120mg of Zn. Broiler chicks given 120g vitamin C with 40mg of Zn (T2) and broiler chicks given 240g and 80 mg zinc/1000l (T3) had similar values for final weight and weight gain (1126.33g and 1184.33g) respectively while the lowest final weight gain (1000.36g) was recorded for broiler chicks given non-supplemented water. The major finding in the present study is the improvement in performance, compared with control, when Zn and vitamin C were added to the water. These results are similar to the findings of (12), who reported a significant improvement in the performance of broiler chicks given minerals and vitamin C in the water. The increment in body weight and average daily gain could be attributed to the addition of key electrolytes in the water for broiler chickens to consume.

In this present study, supplementation with Zinc and vitamin C had no effect on feed consumption across the treatment groups. This result disagreed with the findings of (13), who reported that the highest feed intake was recorded in the control treatment given no mineral and vitamin supplementation, while the lowest feed consumption was recorded for broilers given mineral and vitamin supplementation for whole experimental period of 6 weeks. The discrepancy in these results may be due to the season of rearing and the genotype of birds used in this present study. It was also observed that chicks given 240g Vitamin C with 80mg Zinc had the best feed conversion ratio compared to chicks given water without zinc and vitamin C supplementation. This result is partially supported by (14) and (13), who found considerable improvement in feed conversion efficiency of broilers when broilers were given minerals and vitamins as supplementation with their routine feed. This might be as a result of the inhibitory effect on enzymes released by microorganisms and also on enzymes involved in microbial metabolism (15). The water consumption of broiler chicks given water supplemented with vitamin C and Zn were all similar but

higher than chicks given water without vitamin C and zinc. This result disagreed with the findings of (13), who reported that the highest water intake was recorded in chicks given mineral and vitamin supplementation for first 4 weeks, while the lowest water intake was recorded for broilers given mineral and vitamin supplementation for the whole experimental period of 6 weeks. The difference in the two studies might be attributed to the genotype of chicks and the feed ingredients/materials used in the present study.

Table 3: Performance of Broiler Finisher Chickens as Influenced by Vitamin C and Zinc Supplementation (5- 8 Weeks)

	Vitamin C and Zinc				
Parameters	T1	T2	T3	T4	SEM
Initial weight (g)	1050.00	1051.00	1050.02	1050.10	0.01
Final weight(g)	2450.00	2651.00	2455.00	2578.70	102.24
Weight Gain (g)	1400.00	1601.00	1405.00	1528.7	102.24
Av. daily gain (g)	66.66	76.24	66.91	72.79	8.42
Total Feed Intake (g)	3982.00	4005.00	3951.53	3922.00	42.97
Daily Feed Intake (g/b/d)	189.62	190.11	188.17	186.96	2.05
FCR	2.86	2.51	2.87	2.60	0.21
Water (Litre)	6033.33^{c}	6500.00^{a}	6616.70^{a}	6233.30^{b}	80.75
Mortality (%)	3.55	4.00	3.55	3.00	0.95

a, b,c = Means with different superscript on the same row differ significantly (P<0.05)
SEM = Standard Error of Means
FCR = Feed conversion ratio

Table 4: Carcass Characteristics of Broiler Finisher Chickens as Influenced by Vitamin C and Zinc Supplementation.

	Vitamin C and Zinc				
Parameters	T1	T2	T3	T4	SEM
LW (g)	2318.67^{c}	2322.00^{c}	2440.33^{b}	2546.67^{a}	42.22
CW (g)	1668.60^{b}	1762.00^{b}	1850.65^{ab}	1876.67^{a}	54.99
Dressing (%)	71.96^{b}	75.88^{a}	75.84^{a}	73.69^{ab}	1.11
Primal cuts and organ weights expressed as % of dressed weight					
Breast	11.66^{b}	13.01^{ab}	15.80^{a}	13.13^{ab}	1.02
Wings	3.46^{b}	4.84^{ab}	4.30^{ab}	5.43^{a}	0.49
Thigh	6.26^{b}	7.54^{ab}	7.33^{ab}	8.32^{a}	0.40
Drumsticks	5.57	5.95	6.21	7.27	0.49
Bile	0.44	0.05	0.05	0.05	0.01
Liver	1.13	1.19	1.38	1.38	0.01
Heart	0.24	0.21	0.16	0.22	0.04
Gizzard	1.09^{ab}	0.99^{b}	0.95^{b}	1.22^{a}	0.02
Abdominal fat	0.70^{b}	0.10^{a}	0.23^{a}	0.10^{a}	0.06
Spleen	0.04	0.25	0.05	0.05	0.01
Lung	0.22	0.24	0.26	0.28	0.03

a, b, = Means with different superscript on the same row differ significantly (P<0.05)
SEM = Standard Error of Means
LW=Live weight
CW=Carcass weight

Table 3 shows the effects of dietary supplementation of vitamin C and Zn on performance parameters of broiler finisher chickens (5-8 weeks). Adding vitamin C and Zn to the water did not have significant (P >0.05) effects on the feed intake, final weight, weight gain, and feed conversion ratio across the treatment groups. These results disagreed with the reports of (16, 13), who suggested that broilers may be supplemented with commercially available minerals and vitamins in drinking water over full rearing period, for achieving higher live body weight and efficient feed conversion ratio. However, at the finisher phase dietary treatments had significant effect on water consumption. Chickens administered with zinc and vitamin C recorded the highest value for water consumption. Chickens administered 120g vitamin C with 40mg of Zinc (T2) and 240g Vitamin C with 80mg of Zinc (T3) had the highest values for water consumption (6500.00 and 6616.70 litres) respectively while chickens without zinc and vitamin C had the lowest value (6033.33 litres). This result agrees with the findings of (13), who reported higher water consumption for chickens given water supplemented with mineral and vitamin C. The increased in water intake might be a mechanism to alleviate heat stress, especially when the temperature of the drinking water is below body temperature (17).

Table 4 shows the effect of dietary supplementation of vitamin C and zinc in drinking water of broiler chickens on carcass characteristics. Live weight, carcass weight, dressing percentage breast, wing, thigh, gizzard and abdominal fat were significantly (P >0.05) affected across the treatment groups. Chickens given 360g of Vitamin C with 120mg Zinc in 1000L of water had the best values for live weight, dressed weight, wings weight and thigh weight. The present results are well in line with those of (16), who reported that carcass characteristics and organ weights were considerably improved with supplementation of minerals and vitamins in broiler feed. The dressing percentage, drumstick, liver, heart, spleen and lung were not significantly (P >0.05) affected by the dietary treatments. The abdominal fat pad was observed to be lowest for chickens fed dietary supplemented zinc and vitamin C and the chickens presented with water without dietary supplemented zinc and vitamin C had the highest abdominal fat pad. The addition of zinc and vitamin C to broiler chickens drinking water reduced abdominal fat percentage. This result is similar to the findings of (18), who reported a reduction in fat deposit of broiler chickens fed diets containing organic zinc. This might be as a result of higher bioavailability of vitamin C and zinc leading to higher fat metabolism in the liver, also increasing the lipid synthesis for broilers through controlling the activities and gene expressions of lipogenic enzymes (19, 20). However, generally it was obvious that inclusion of vitamin C and Zn had significant effects on growth performance of broiler at the starter phase than at the finisher phase. It showed clearly that chicks' diets should be fortified with essential minerals and vitamins for improved growth.

Conclusion and Applications

1. The present investigations showed that Zinc and vitamin C supplementation in drinking water at the starter phase showed better influence on feed conversion ratio and performance of broiler chickens.
2. Adding a combination of vitamin C and Zinc in drinking water of growing broiler chickens improved growth performance and carcass quality in a dose-related way in broiler chickens. Chickens administered 240g Vitamin

C with 80mg of Zinc (T3) had the best growth performance.

Conflict of interest

Authors declare that there are no conflicts of interest.

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