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Effect of Vitamin C (Ascorbic Acid) on Growth Performance of Broilers

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Abstract

Frequently changing weather conditions threaten small-scale broiler production. This study aimed to determine the effects of adding vitamin C to drinking water on the growth performance of broilers during winter. A naturally ventilated open-sided broiler house at the Experimental Farm of the University of Venda was used from July to August. The house was divided into pens with an infrared light, a 12 L manual drinker, and a tube feeder. We used 375 Ross 308-day-old chicks at 25 birds per pen, and the experiment ran till day 42. A completely randomised design with three replications was used with five Vitamin C inclusion levels of 0, 1, 1.5, 2, and 2.5 g/L. Commercial diets, standard medication, and vaccines were used. In-house temperature, body weight, feed and water provided, leftovers, and mortalities were recorded. Feed and water intake, water-to-feed ratio, weight gain, FCR, vitamin C intake, and mortality rate were calculated. Data was analysed using the GLM procedure of Minitab, considering the broilers' age. Vitamin C affected ($P<0.01$) water intake and Vitamin C consumption. Broilers on 1 and 1.5 g/L drank more water (about 240 mL/b/d) than the 213 mL/b/d drank by those on 0 g/L. Furthermore, the intake was similar among broilers given Vitamin C. The lowest vitamin C consumption was 242 mg/b/d for 1 g/L, and the highest was 563 g/b/d for 2.5 g/L. We concluded that vitamin C in drinking water only affects water intake and consumption. Therefore, adding vitamin C to broilers' drinking water had no growth benefits.

Keywords: chicken, cold stress, water intake, winter season, subtropical region.

Introduction

Climate change leads to frequent deviations in weather patterns with relatively cold and hot conditions. These conditions make it difficult for small-scale broiler producers to achieve expected growth performance as they frequently lack the resources to adjust their management practices to counter these conditions (SAPA 2022:9-10). Most small-scale farmers use semi-environmentally controlled open-sided houses to rear the birds (SAPA 2022:2; Saunders, 2022). Under this housing system, birds are more susceptible to frequently changing weather conditions (Ahmadu et al., 2016; Tavakolinasab & Hashemi, 2025). Furthermore, the feed resources accessible to these farmers are sourced from local dealers and/or agents who sell standard commercial broiler diets (SAPA 2022:7; Das et al. 2024). These standard diets often contain varying energy content depending on the intended season of their use, like high-energy high-protein for winter and low-energy high-protein for summer, but their nutrient content cannot be adjusted daily (Maharjan et al., 2021; Khuguvhila, 2024, pp. 41-41).
In the developing world, challenges faced by small-scale farmers are not limited to the effects of climate change; they include limited finance, inaccessible markets, and inadequate technical know-how and equipment, among others (Kpomasse et al., 2021; Dhillon & Moncur, 2023; Adjei-Mensah et al., 2024). In South Africa, small-scale broiler farmers are those producing ≤ 2000 birds per batch for sale to consumers, small traders and abattoirs (Ralivhesa, Van Averbeke and Siebrits, 2013), and these farmers are under the subsistence and the significantly lower end of the small commercial classes declared by the South African Poultry Association (SAPA 2022:2). The options of small-scale farmers are limited to what they can afford and available support from the state. These should guide the focus of research geared to benefit them. Under stressful conditions, the ability of birds to synthesise vitamin C is insufficient, making its supplementation key (Ahmadu et al., 2016). Vitamin C is known to help broilers cope with environmental stress induced either by cold or heat conditions. Supplementing 150-250 mg/kg of feed improved the growth performance of broilers subjected to heat stress (Elkheir et al., 2008; Ahmadu et al., 2016; Tavakolinasab & Hashemi, 2025), but 500-750 mg/kg decreased it (Elkheir et al., 2008). Diverse effects of vitamin C on growth performance during cold stress were reported. Poor performances were observed at 500-1000 mg/kg of feed (Yang et al., 2014; Zangeneh et al., 2020). Furthermore, Zangeneh et al. (2020) contended that not only does the inclusion level of vitamin C affect growth performance during cold stress, but adequate levels are also subject to the stress level, broiler strain, and diet type. Small-scale broiler farmers cannot supplement vitamin C on feed, as it cannot be mixed with the bagged standard commercial diets. Hence, interventions in drinking water are most plausible.
In this study, we investigated the effects of adding vitamin C to the broilers' drinking water on the growth performance of broilers under semi-environmentally controlled housing during a subtropical winter. We hypothesised that adding vitamin C would improve growth performance by enabling the broilers to cope with cold.

Methods and materials

Location of the study

We conducted this study at the experimental farm of the University of Venda (22°58'32"S, 30° 26'45 "E; altitude 596 m above sea level) in Thohoyandou, Vhembe District, Limpopo province, in South Africa. This study was conducted during winter and lasted 35 days from when broilers were 8 days old till day 42. Thohoyandou receives an average annual rainfall of 800 mm, of which 95% occurs between October and March (Mzezewa & Gwata, 2012). During this study, the recorded atmospheric temperature (using a Thermometer Wall Hang Brannan) in the broiler house ranged between 5 and 27 °C, with the average minimum and maximum of 8 and 21°C, respectively.

Acquisition and preparation of vitamin C

Vitamin C powder (Vita Pro Orange Vitamin C 1000 mg Powder) was bought in 250 g plastic containers from a pharmacy in Thohoyandou. The containers were kept at room temperature, and the powder was used earlier than the use-by date. The daily quantities of the powder to be used were scooped into a 50 mL glass beaker using a spatula, weighed using an Adam Equipment PW 254- PW Analytical Balance (22 ADAM® PW 254) with a capacity of 250 g, and stored in 50 mL plastic containers, which were sealed with lids. Then, containers with remaining powder were covered using their lids. A completely randomised design was adopted in this experiment with five inclusion levels of Vitamin C (0, 1, 1.5, 2, and 2.5 g/L of tap water) and 3 three replications.

Preparation of the broiler house

Dry cleaning was performed using brooms, shovels, and wheelbarrows to dispose of the litter materials from the previous batch of broilers. Then, the floor was swept using brooms. Virukill was mixed with water in buckets at 2 mL/L to clean the roof, walls, floors, and equipment (drinkers and feeders). After cleaning and disinfecting, the house was kept empty for 10 days, allowing disinfectant to penetrate and kill the microbes and for the house to dry completely. The floor was covered with wood shavings of 7.5-10 cm height to provide a comfortable and absorbent bedding material for the broilers. A foot dip was made available at the entrance of the broiler house.

Research animals, holding pens, and health management

Two thousand Ross 308 broiler chicks were bought from Alfa Chicks (ALFA CHICKS (Pty) Ltd, Pretoria, South Africa), of which 375 were selected randomly and used in this research. These broilers were reared in a house that simulated local small-scale production practices described by Benyi et al. (2015). The broiler house was a naturally ventilated 17.0 m × 9.0 m open-sided house within which steel-frame/d/mesh-wire experimental pens measuring 150 cm length × 144 cm width were constructed and stocked with 25 birds per pen. Each pen had one adjustable tube feeder of 430 mm in height x 390 mm in diameter and a 12L manual drinker of 400 mm in height x 360 mm in diameter. The house had standard lights, which were on throughout the experiment, and infrared lights were used for brooding until day 21. Broilers were provided with soluble vitamins and electrolytes in Stresspac (Virbac©, Samrand Business Park, South Africa) daily during days 1-6. They were vaccinated against IB on day 10, Gumboro on days 12 and 18, and Newcastle on day 25.

Diets

Commercial budget broiler diets (starter, grower, and finisher) produced on 09-06-2023 were used in this experiment. The nutrient compositions of these diets are provided in Table 1. The periods during which these diets were provided to the broilers were: day 1-21 starter, day 22-35 grower, and day 36-42 finisher. Broilers had access to feed all the time and were deprived of water during the morning refills only.

Table 1 Chemical composition (g/kg) of the commercial broiler diets used in this study

Nutrient	Diet		
	Starter	Grower	Finisher
Protein (min)	200	180	160
Moisture (max)	120	120	120
Total Lysine (min)	12	10	9
Fat (min)	25	25	25
Fibre (max)	50	60	70
Calcium (min-max)	8-12	7-12	6-12
Phosphorus (min)	6	5.5	5

Source: labels on the bags of feed.

Data collection
Temperatures inside the broiler house were recorded twice daily at 7 am and 3 pm using a Thermometer Wall Hang Brannan. Broilers and feeds were weighed using an XPK-Bench Series Precision Balance (Labotec Pty/Ltd, South Africa). All birds in each pen were weighed at the start of the experiment (day 8) and at the end of each week during the experiment. Feed was weighed when offered and remained in the tube feeders at the end of each week. A 1000 mL plastic spouted measuring cylinder was used to measure the quantity of water given to the broilers each morning and again to measure the quantity left in the drinkers the following morning. The morbidity of the broilers was assessed using visual observation twice daily, during the morning and late afternoon. Dead birds were recorded and removed from the house for disposal daily.

Mathematical calculations and statistical analysis
Averages of body weight, daily weight gain, daily feed and water intake, water-to-feed ratio, percentage of mortality, and FCR were calculated for each of the pens. Daily vitamin C consumption was computed by multiplying its inclusion rate by the daily water consumption. The square root transformation was used to transform the mortality data. One-way ANOVA was used to assess differences in initial, and day-42 body weights across Vitamin C inclusion levels, and other parameters were subjected to a General Linear Model using MINITAB software (version 21.4.1). We used the GLM procedure to analyse the effects of the week (age of broilers) and the Vitamin C level on the growth performance of Ross 308 broilers. The Tukey tests were conducted to separate means.

Results and Discussion
Table 2 presents the growth performance (means) of Ross 308 broilers subjected to Vitamin C in drinking water for the experimental period (days 8-42). Birds were of similar ($P>0.05$) body weights at the start of the experiment on day 8 (168 ±1.95 g). The effect of birds' age showed standard trends (positive relationships) for weight gain, feed consumption, water intake, water-to-feed ratio, and vitamin C intake. However, the trends for FCR and mortality were contrary to standards. The findings show a poor FCR of about 2.25 for days 8-21 and a better FCR of about 1.60 for days 22-42. Contrary to these findings, Aviagen (2022) indicated that FCR for Ross 308 broilers is negatively related to birds' age, being 0.20 for day-old chicks and 1.53 for day 42. The ability of young birds to get into tube feeders and spill some of the feed could be the cause of the poor FCR observed in this study. No mortality was recorded during days 8-14, but 0.9% was recorded during days 22-28. Broiler mortality is expected to be higher for younger birds than older ones. In this study, we could not deduce the causes of deviations in standard mortality trends.
Table 2 shows that including vitamin C in broilers' drinking water affected ($P<0.01$) water intake and vitamin C consumption. Broilers on 1 and 1.5 g/L drank more water (about 240 mL/b/d) than the 213 mL/b/d drank by those who did not receive the vitamin (Table 2). Furthermore, water consumption was similar among vitamin C inclusion levels. The results show that the increase in the inclusion level of vitamin C increased its consumption, with the least consumption of 242 mg/b/d observed at 1 g/L and the highest of 563 g/b/d at 2.5 g/L. The similarities in water drunk by broilers among the vitamin levels caused the observed positive relationship between the level of vitamin C's inclusion and its consumption.
Body weight on day 42 and during the experimental period (day 8-42), body weight gain, feed intake, water-to-feed ratio, FCR, and mortality were not affected ($P>0.05$) by the inclusion of vitamin C in drinking water. For the experimental period, the overall means for these variables were: 23330 ±29.94 g/b weight on day 42, weight gain 62 ±3.471 g/b/d, feed consumption 108 ±6.02 g/b/d, water to feed ratio 2.17 ±0.048, FCR 1.9 ±0.047, and mortality 0.35 ±0.095 %. The results are consistent with the literature, which indicates that vitamin C did not affect feed intake, FCR (Nemati et al., 2017), and body weight gain (Azaka et al., 2024). On the contrary,

these authors reported improved feed intake and FCR (Azaka et al., 2024) and body weight gain (Nemati et al., 2017).
The higher water intake of vitamin C by broilers on 1 and 1.5 g/L of 29 and 25 mL/b/d, respectively, compared to those that did not receive vitamin, did not yield differences in feed intake and the water-to-feed ratio among these inclusion levels. Hence, this higher water intake did not produce higher weight gain for broilers on levels 1 and 1.5 g/L. The results for the water-to-feed ratio are consistent with the literature and information about the Ross 308 broiler strain, which indicates that broilers drink twice as much water as they consume feed (May & Lott, 1992; Obaia, 2015; Aviagen, 2022). We deduced that the higher water intake of about 27 mL/b/d was inadequate to cause an increase in feed intake; hence, the weight gain did not improve either. The commercial feeds used in this study had adequate vitamin C for growth and acclimatisation to the subtropical winter of the study area. We deduced that adding 1-1.5 g/L of vitamin C to the drinking water of broilers fed commercial feeds might improve their water intake, but inclusions of ≤2.5 g/L will not affect the body weight, body weight gain, feed intake, FCR, and mortality rate.

Table 2 Growth performance (means) of Ross 308 broilers subjected to vitamin C in drinking water (days 8-42)

Factor	d8 weight (g/b)	d42 weight (g/b)	Weight gain (g/b/d)	Feed consumed (g/b/d)	FCR	Water intake (ml/b/d)	WI/FC ratio	Vitamin C intake (mg/b/d)	Mortality (%)
Week (days)									
8-14	-	-	25^{a}	51^{a}	2.4^{d}	113^{a}	1.91^{ab}	197^{a}	0.0^{a}
15-21	-	-	35^{b}	71^{b}	2.1^{c}	145^{b}	2.04^{b}	257^{a}	0.4^{ab}
22-28	-	-	62^{c}	76^{c}	1.2^{a}	219^{c}	2.88^{d}	387^{b}	0.9^{b}
29-35	-	-	82^{d}	146^{d}	1.8^{b}	324^{d}	2.22^{c}	578^{c}	0.3^{ab}
36-42	-	-	104^{e}	191^{e}	1.8^{b}	343^{d}	1.79^{a}	599^{c}	0.1^{ab}
SEM	-	-	1.31	1.65	0.03	4.78	0.033	14.90	0.19
Vitamin C (g/L)									
0	166	2254	60	107	1.9	213^{a}	2.10	-	0.5
1	170	2307	61	110	1.9	242^{b}	2.24	242^{a}	0.1
1.5	169	2423	64	112	1.8	238^{b}	2.22	357^{b}	0.4
2	168	2330	62	109	1.9	226^{ab}	2.14	452^{c}	0.3
2.5	166	2337	62	108	1.8	225^{ab}	2.15	563^{d}	0.5
SEM	4.90	61.8	1.31	1.65	0.03	4.78	0.033	12.90	0.19
P values									
Week (W)	-	-	0.000	0.000	0.000	0.000	0.000	0.000	0.027
Vitamin C (VC)	0.968	0.558	0.246	0.460	0.335	0.003	0.055	0.000	0.794
W x VC	-	-	0.671	0.831	0.439	0.679	0.179	0.000	0.517

Source: Experiment results (2023).

Note: Table 2 above shows the number of observations (n) as 15 for the analyses of all parameters except for the n = 12 for vitamin C consumed, g/b/d grams per bird per day, FCR feed conversion ratio, and *mL/b/d* millilitres of water per bird per day, *SEM* standard error of means. Means within a column with different superscripts are significantly different (P<0.05).

We found that adding 1-2.5 g/L of vitamin C in broilers' drinking water had no effects on growth performance, contrary to the literature, which indicates that including 150-250 mg/kg of vitamin C improves performance (Elkheir et al., 2008; Ahmadu et al., 2016; Tavakolinasab & Hashemi, 2025). Hence, the deduction that this lack of effects could be mainly due to rapid oxidation associated with adding vitamin C into neutral to slightly alkaline tap water with a pH range of 6.5-8.5 (Golubitskii et al., 2007; Sheraz et al., 2015). In addition to this likely cause of deviation, Zangeneh et al. (2020) contended that adequate levels of vitamin C during cold stress depend on stress level, broiler strain, and diet type.

Conclusions

We investigated the effects of adding vitamin C to the drinking water of Ross 308 broilers fed commercial diets during winter in a subtropical environment. Adding 1-1.5 g/L of vitamin C could improve water intake, and adding ≤2.5 g/L will not affect body weight, feed intake, weight gain, feed conversion ratio, and mortality. Hence, adding ≤2.5 g/L of vitamin C in drinking water during winter will not improve the growth performance of broilers under subtropical conditions. The study findings imply that for small-scale farmers to remain economically viable, particularly resource-stricken ones, adding vitamin C to the drinking water of broilers is non-value-adding. Furthermore, this implies that potential farmers intending to raise broilers under similar environmental temperatures should avoid adding vitamin C as it does not improve growth, but rather water intake.

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Data availability: The data presented in this study are available on request from the corresponding authors.

Ethics approval: This study was performed per the “Animals Protection Act 71 of 1962” and the “Protection of Animals Amendment Act 7 of 1991” of the Republic of South Africa. Approval was granted by the Animal, Environment and Biosafety Research Ethics Committee of the University of Venda (FSEA/23/ANS/03).

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