

EFFECTS OF HOT RED PEPPER (*Capsicum annuum*) AS AN ANTIOXIDANT ON GROWTH PERFORMANCE OF BROILERS

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Abstract: Broilers reared in semi-environmentally controlled housing are prone to stress caused by within-season fluctuation of weather conditions linked to climate change. Plant-based derivatives, such as hot red pepper (HRP), are among the alternative phytochemicals rich in antioxidants, which could reduce the effects of stress in broilers. This study assessed the effects of supplementing HRP in drinking water on the growth performance of Ross 308 and Cobb 500 broilers until day 21. The experiment was conducted in a naturally ventilated broiler house at the University of Venda's Experimental Farm, South Africa. A 2 (broiler strains) × 3 (HRP levels of 0, 10, and 15 g/L) factorial design with three replications was adopted. The HRP was oven-dried and ground to a fine powder that passed through a 200 µm sieve. The GLM procedure in Minitab version 21.4.1 was used to analyse the data, and the Tukey test was used to separate the means. Strain × pepper interactions affected feed consumption (FC) during days 15-21 ($P < 0.05$) and days 8-21 ($P < 0.01$). Ross 308 on 15 g/L had a higher FC i) of 99 g/b/d than the 85 g/b/d observed on 0 g/L for this strain, and ii) of 81 g/b/d than the 72-75 g/b/d for Ross 308 on 0 g/L and for Cobb 500 on all pepper levels, respectively. Pepper affected ($P < 0.05$) FCR during days 15-21. FCR was better for 0 g/L (1.32) than for 15 g/L (1.50). Strain affected ($P > 0.01$) weight gain during days 15-21 and day-21 body weight. Ross 308 gained more weight (68 g/b/d) and was heavier (948 g) than Cobb 500 (62 g/b/d and 899 g, respectively). It was deduced that the FC of Ross 308 increased when the HRP level increased, while that of Cobb 500 did not. The similarities in FCR (1.2 - 1.5) among treatments lead to the conclusion that supplementing 15 g/L HRP in drinking water benefits Ross 308 (a heavier strain). The inclusion of 15 g/L HRP for Ross 308 will benefit small-scale farmers, as birds will reach the targeted market weight earlier, resulting in savings on feeding costs and improved economic sustainability.

Keywords: antioxidant, broilers, growth performance, hot red pepper, naturally ventilated housing, phytochemical

1. Introduction

The rate at which broilers convert feed into muscle development makes them susceptible to stress and metabolic disorders. This susceptibility increases when these birds are reared under semi-environmentally controlled housing due to unpredictable weather patterns associated with climate change (Parandoosh et al., 2023). Dietary synthetic antibiotics are used, mainly in the developing world, to counter these susceptibilities. However, the rise of antibiotic-resistant pathogens (associated with the concept 'antimicrobial resistance/AMR') has amplified the need for alternative growth-promoting additives to safeguard the health of humans and animals (Rafiq et al., 2022). Herbal/phytochemical additives are among the key alternative growth promoters because they modulate pathways linked to

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stress and oxidation (Farag et al., 2021; Orłowski et al., 2018; Rafeeq et al., 2023). Phytobiotics are phytochemical compounds derived from plants, which are classified into various categories, including phenolic compounds, organosulfur compounds, nitrogen-containing compounds, phytosterols, alkaloids, and carotenoids. (Dhama et al., 2018; Liu, 2004; Martel et al., 2020). The modulation abilities of phytobiotics enable them to increase feed consumption, digestion, and absorption, thereby influencing utilization and growth (Rafeeq et al., 2023). Furthermore, phytobiotics have antimicrobial properties and influence physiological and metabolic processes in animals by increasing appetite and enhancing the secretion of digestive enzymes (Parandoosh et al., 2023; Righi et al., 2021).

Spices contain natural bioactive phytochemicals that have been reported to promote growth in broilers. Ginger root extract inclusion at $\leq 1.5\%$ improved weight gain (WG) and feed conversion ratio (FCR) but did not affect feed consumption (FC) (Dosu et al., 2023). Brisibe et al. (2008) reported that 10% *A. Annuum* improved feed consumption (FC) and weight gain (WG), but did not affect the feed conversion ratio (FCR). Aniseed inclusion at 20 and 40 ml/L improved FC and WG, and decreased FCR (Durani et al., 2007). Saeid and Al-Nasry (2010) reported that 0.1-0.3% of Coriander improved WG and decreased FC and FCR, and Hosseinzadeh et al. (2014) indicated that 1.5-2.5% Coriander improved WG and decreased FCR. Cumin inclusion at 1% and 1.5% improved FC and WG, without affecting FCR (Yasar et al., 2011), that at 0.5% and 1% improved WG and decreased FC and FCR (Al-Kassie, 2010), and that at 2% improved FC and WG and decreased FCR (Guler et al., 2006). Mohammed and Abbas (2009) reported that 1-3 g/kg of Fennel improved WG and decreased FC and FCR. Garlic inclusion at 5, 10 and 15 ml/L improved FC and WG and decreased FCR (Javed et al., 2009; Zeb et al., 2021). The inclusion of turmeric at 1.5% improved WG and FCR, but did not affect FC (Eko et al., 2020). It is deduced that inclusion of species at $\leq 10\%$ tends to improve growth performance without affecting the health and well-being of the broilers.

Peppers (*Capsicum* spp.), one of the oldest domesticated and utilized crops, are bestowed with a wide range of natural bioactive phytochemicals, making the plant a very valuable spice with health-beneficial aspects, and they are readily accessible and regarded as a spice for cuisine purposes for humans (Duranova et al., 2022; Hamed et al., 2019). Peppers can be cultivated and consumed as fresh vegetables and dried spices; their phytochemical of primary interest is capsaicin, a phenolic and capsaicinoid compound (Akhtar et al., 2021). Capsaicin contributes to the characteristic spicy flavour of peppers. Furthermore, peppers have phenolics, ascorbic acid, carotenoids, and flavonoids. Like other spices, peppers can act as antioxidants, antimicrobials, and anti-inflammatory agents (Duranova et al., 2022; Hernández-Pérez et al., 2020). As antioxidants, peppers can counteract free radicals that can damage cells and contribute to the prevention of oxidative stress. These capabilities make peppers candidates for use in adapting to the unpredictable weather conditions resulting from climate change when broilers are raised under semi-controlled environmental conditions. Climatic change results in extreme weather conditions, such as excessive cold spells and heatwaves, which occur within a single season, making standard seasonal broiler management practices unsuitable (Nyoni et al., 2019, 2022; Oke et al., 2024). Small-scale broiler farmers are in a dire situation, as they often struggle to cope with the effects of climate change due to their limited production infrastructure and low financial endowment (Adjei-Mensah et al., 2024; SAPA, 2022).

Broiler strains are developed for 'rapid growth, feed efficiency, and consistent performance' (Fidarfeed.com, 2025). However, strains differ in 'i) housing, feeding, and management needs, ii) health and hardiness, iii) feed conversion efficiency, iv) growth rate, and v) meat yield and quality' (Fidarfeed.com, 2025). Furthermore, on these attributes, Ross 308 is superior to Cobb 500, as it is easily

adaptable (suitable for fluctuating weather conditions) and maintains consistent feed intake and conversion even when feed quality is inconsistent.

This study focused on hot red pepper. Pepper fruit could be processed whole, or its selected bioactive compounds could be extracted in addition to the broilers' diet or drinking water. Extracting bioactive compounds from hot red peppers requires specialized equipment for processing and the knowledge and skills that small-scale broiler farmers often lack. Hence, extracting bioactive compounds from hot red pepper is not feasible for small-scale farmers. Most small-scale farmers depend on commercial feeds from retailers because producing diets is not economically viable. Mixing hot red pepper powder with commercial broiler feeds is difficult because they are in crumb and pellet forms. Therefore, adding pepper to broilers' drinking water is a practicable option for small-scale farmers. Younis and Abdel-Latif (2017) observed that hot pepper induces better growth performance when provided in broilers' drinking water than with feed. Furthermore, pepper is considered effective on younger broilers till 21 days of age. Capsaicin is known to improve the development of the small intestine and increase the villous surface area. It increases enzyme (lipase, trypsin, and amylase) activities, thereby improving the digestibility of the feed and absorption of the nutrients (Li et al., 2022; Long et al., 2021; Li et al., 2025; Fan et al., 2023). Furthermore, feed utilisation efficiency, i.e., better growth, is enhanced by increased villi size (height and width). At low doses (5 mL/kg), capsaicin supports mucosal integrity and promotes the functioning of beneficial microbes (Li et al., 2025; Fan et al., 2023). Broiler production under semi-environmentally controlled housing may be affected by oxidative stress associated with frequent fluctuations in ambient temperatures, which are linked to climate change (Parandoosh et al., 2023). Furthermore, these birds could benefit from antioxidant-rich phytogetic additives (Ognik et al., 2016). This study investigated the antioxidant potential of hot red pepper (*Capsicum annum*) on the growth performance of broilers. The aim was to determine if hot red pepper could improve the growth performance of broilers under naturally ventilated broiler housing.

2. Materials and Methods

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).

The ripe hot red pepper of the "Chisa cultivar", harvested a day before collection and stored in 20 L plastic buckets, was bought from a local farmer in Dzwerrani village, Thulamela Local Municipality, Vhembe District, South Africa. Upon arrival, the peppers were cleaned with tap water to remove surface contaminants, and paper towels were used to dry them. Aluminium trays were used to store pepper for further processing after the removal of stalks. The Memmert Model 500 oven was used to dry peppers at 70°C for 32 hours to a constant weight. Then, dried peppers were ground using a Kambrook KAM 6484 glass blender to pass through a 200 µm King Test laboratory sieve. Pepper powder was stored in airtight glass containers to preserve and prevent moisture absorption. A spatula was used to scoop the powder into a 50 mL glass beaker and weighed using an Adam Equipment PW 254- PW Analytical Balance (22 ADAM® PW 254) with a capacity of 250 g to determine the daily quantities to be used. These predetermined quantities were stored in 50 mL plastic containers and sealed with lids. The processed pepper powder was thoroughly mixed (manually) with broilers' drinking water (clean from

the tap) every morning at 0, 10, and 15 g/L. Broilers were deprived of water for no more than an hour during morning refills.

The trial was conducted during winter at the University of Venda's Experimental Farm (Latitude 22°58'32'S, Longitude 30°26'45'E), Thohoyandou, Limpopo Province, South Africa. The area experiences cold, dry winters and hot, rainy summers with an average annual rainfall of 800mm between October and March (Mzezewa and Gwata, 2012). Furthermore, the area's temperatures range between 12 and 26 °C in winter. A naturally ventilated, open-sided, brick-walled broiler house measuring 17.0 m × 9.0 m was used. The house is built to a meter in height, using bricks, followed by 2.5 cm wire mesh to the roof. Heavy PVC poultry curtains were used to control air movement into and out of the house. This broiler house is like those used by small-scale farmers in South Africa. Before chicken placement, the house was subjected to standard dry and wet cleaning and kept empty for two weeks in preparation for the experiment. It was partitioned into pens of 150 cm length × 144 cm width, in which the floor was covered with sawdust of 7.5 cm in height as bedding. Furthermore, each pen was equipped with a tube feeder (430 mm height x 390 mm diameter), a 12 L water fount (400 mm height x 360 mm diameter), and a 175-W infrared bulb for heating. The light was provided by 40-W fluorescent tubes at all times.

Cobb 500 and Ross 308 chicks of mixed sex were reared separately till day 7 to acclimatize. The strain was used as a block with a hot red pepper additive applied across strains, leading to a 2 (strain) × 3 (levels of pepper inclusion) factorial design with three replications. Chicks were given vitamins and minerals in the form of Phenix® Stresspac for Poultry and Ostriches (Virbac©, Samrand Business Park, South Africa) from day 1 to 6 days of age and vaccinated for infectious bronchitis on day 8 and Gumboro on days 12 and 18. A digital weighing balance was used to determine the birds' weight on day 8 and at the end of each week. Chicks were weighed. After the initial weighing, the birds were weighed weekly until they were 22 days old. The Chickens were fed commercial broiler starter with this nutrient composition (% minimum/min or maximum/max): moisture 12 max, crude protein 20 min, lysine 1.3 min, fat 2.5 min, crude fibre 5 max, calcium 0.8-1.2, phosphorus 0.6 min, and sodium 0.2 max. Feed was always accessible to the broilers. On Day 8, 13 chicks of a specified strain were randomly allocated to a pen designed for that strain, resulting in 117 Cobb 500 and 117 Ross 308 being used.

Weights of feed and birds were determined using XPK-Bench Series Precision Balance (Labotec Pty/Ltd, South Africa). Broilers were weighed on day 8 and at the end of each subsequent week, while feed weight was determined when offered and at the end of each week. At day 8 of age, the water provided was recorded. Starting on day 9 and continuing until day 22, the quantities left and the new water added were recorded each morning between 8:00 and 9:00 am. The welfare of the broilers was monitored daily in the morning and late afternoon. Mortality was recorded when experienced. Body weight, feed consumption, water intake, weight gain, and feed conversion ratio were calculated using the collected data and expressed on a per-bird basis. These variables have 18 observations (linked to 18 experimental pens) each, which were used for statistical analysis. An analysis of variance for a 2 × 3 factorial in a randomized block (strain) design was conducted using the GLM procedure in Minitab version 21.4.1. Treatment means were compared using the Tukey test. Data were significant at $p < 0.05$ and highly significant at $p < 0.01$.

Averages of body weight, weight gain, feed and water intake, and FCR were calculated for each of the 18 pens. Daily hot red pepper consumption was computed by multiplying its inclusion rate by the daily water intake. Data was subjected to normality tests, and those for weight gain days 8-14 and 15-21, feed consumption, water intake days 8-14, and feed conversion ratio days 15-21 were transformed with the formula $\text{Idf.Normal}(X, \mu, \sigma)$, where X = Original variable, μ = mean of the variable, and σ = standard

deviation of the variable. The analyses for variances were conducted using the GLM procedure in Minitab software (version 21.4.1), and the Tukey's test was used to separate means where significant differences ($P < 0.05$) were observed.

3. Results

Table 1 presents the effects of strain and hot red pepper on the growth performance of broilers during the starter period (days 8-21). The interactions between strain and pepper inclusion level affected feed consumption (FC) during days 15-21 ($P < 0.05$) and days 8-21 ($P < 0.01$) but did not affect ($P > 0.05$) other growth parameters. Ross 308 on 15 g/L had higher days 15-21 FC of 99 g/b/d than the lower 85 g/b/d observed on 0 g/L for this strain. For days 8-21, Ross 308 on 15 g/L had a higher FC of 81 g/b/d than the lower levels, ranging from 72-75 g/b/d for Ross 308 on 0 g/L and for Cobb 500 on all pepper levels.

The initial body weight, on day 8, Ross 308 was heavier ($P < 0.01$) than Cobb 500, 172 g compared to 144 g. During days 15-21, the strain affected ($P < 0.01$) weight gain (WG) and day-21 body weight (BW). Ross 308 gained more weight (68 g/b/d) and was heavier (948 g) than Cobb 500 (62 g/b/d and 899 g, respectively).

The inclusion level of pepper affected ($P < 0.05$) FCR during days 15-21. Broilers on 0 g/L had better FCR (1.32) than those on 15 g/L (1.50).

The strain and pepper inclusion level did not affect ($P > 0.05$) i) FC, water intake (WI), WG, day-14 BW, and FCR, during days 8-14, ii) WI during days 25-21, and iii) WI, WG, and FCR, during days 8-21. The overall means (\pm SEM) for these variables were i) for days 8-14: FC = 59 \pm 0.79 g/b/d, WG = 44 \pm 0.69 g/b/d, day-14 BW = 467 \pm 5.72 g, and FCR = 1.34 \pm 0.033, and iii) for days (8-21): WI = 207 \pm 2.77 mL/b/d, WG = 55 \pm 0.56 g/b/d, and FCR = 1.39 \pm 0.020. Mortality was rare (0.85%) and was observed in Cobb 500 birds not subjected to pepper.

Discussions

In this study, it was observed that adding 15 g/L (i.e., 1.5% inclusion level) of hot red pepper to the drinking water of Ross 308 (a heavier strain) improved their feed consumption, whereas 10 g/L (1%) did not. This observation suggests that the appetite was improved at a higher inclusion level. Similarly, feed consumption was reported to be constant by Younis and Abdel-Latif (2017) at 1% hot pepper and by Parandoosh et al. (2023) at 0.025% herb extract mixture. On the contrary, Al-Kassie et al. (2012) found that adding 0.25% of a mixture of hot red pepper and black pepper to broilers' feed improved their consumption, but higher levels $\geq 1\%$ had no effect, and Islam et al. (2018) found that adding $\leq 0.75\%$ led to improvements.

The observed higher FCR at 15 g/L during days 15-21 was attributed to the higher FC for days 8-21 for that treatment, which were both higher than the values for the control (0% inclusion level). These observations that broilers on higher pepper levels (1.5%) consumed more feed, leading to poor FCR, could be the reason studies investigated inclusion of spices of $\leq 1\%$ (Al-Kassie et al., 2012; Younis and Abdel-Latif, 2017; Parandoosh et al., 2023; Islam et al., 2018). However, no conclusions could be drawn solely from the inclusion of pepper, as the broiler strain was also a factor.

In this study, the inclusion of hot red pepper at 1% and 1.5% did not affect BW, WG, and WI during days 8-21. However, improved day-21 weights were reported by Younis and Abdel-Latif (2017) at 1% pepper inclusion, and by Parandoosh et al. (2023) at 0.025% of the herb extract mixture. This study's

findings are consistent with the literature, which reports that adding 1% hot red pepper to drinking water does not affect weight gain, water intake, and feed conversion ratio (Younis and Abdel-Latif, 2017). However, this could be attributed to the provision of hot red pepper in water, given that, for pepper on feed, improvements were reported for weight gain with inclusions of pepper at $\leq 0.75\%$ (Al-Kassie et al., 2012; Islam et al., 2018); of the herb extract mix at 0.025% (Parandoosh et al., 2023), and FCR (with inclusions of $\leq 0.75\%$ inclusion (Al-Kassie et al., 2012). Literature also reported a lack of effects at various inclusion rates: Islam et al. (2018) at $\leq 0.75\%$ pepper on feed, and Parandoosh et al. (2023) at 0.025% herb extract mix in water.

In this study, the observations that Ross 308 broilers consumed more feed and were heavier at day 21, as they are a heavier strain than Cobb 500, are consistent with the literature (Benyi et al., 2015; Younis and Abdel-Latif, 2017). It could be the effortless adaptability of Ross 308, which led to higher FC, as this strain is better suited for fluctuating weather conditions than Cobb 500 (Fidarfeed.com, 2025). Furthermore, Ross 308 is known for its consistent feed intake and conversion, even when feed quality is inconsistent, compared to Cobb 500.

Table 1: Effects of strain and hot red pepper growth performance during the starter period (day 8-21)

Factor		Day 8-14						Day 15-21					Period (day 8-21)			
Strain	Pepper (g/L)	BW d8 (g/b)	FC (g/b/d)	WI (ml/b/d)	WG (g/b/d)	BW d14 (g/b)	FCR d8-14	FC (g/b/d)	WI (ml/b/d)	WG (g/b/d)	BW d21 (g/b/d)	FCR	FC (g/b/d)	WI (ml/b/d)	WG (g/b/d)	FCR
Cobb	0	149	55	174	43	470	1.36	92 ^{ab}	253	59	899	1.40	74 ^a	213	54	1.40
	10	138	60	151	46	461	1.37	94 ^{ab}	266	64	906	1.57	75 ^a	207	55	1.38
	15	147	63	161	43	443	1.47	90 ^{ab}	255	64	891	1.46	73 ^a	205	53	1.39
Ross 308	0	164	58	153	44	468	1.25	85 ^a	251	67	943	1.24	72 ^a	209	56	1.30
	10	177	60	150	44	481	1.24	94 ^{ab}	256	70	963	1.36	76 ^{ab}	202	56	1.37
	15	175	63	143	44	478	1.34	99 ^b	265	66	938	1.53	81 ^b	205	55	1.49
SEM		3.50	1.96	4.92	1.12	8.16	0.046	1.38	6.65	1.03	11.10	0.032	0.68	4.42	0.84	0.025
Strain	Cobb 500	144 ^a	58	162	44	458	1.28	92	258	62 ^a	899 ^a	1.48	74 ^a	205	54	1.39
	Ross 308	172 ^b	59	149	44	476	1.40	92	257	68 ^b	948 ^b	1.38	77 ^b	208	55	1.39
	SEM	2.47	0.68	3.44	0.782	5.77	0.033	0.98	4.70	0.72	7.88	0.023	0.48	3.13	0.59	0.017
Pepper (g/L)	0	156	57	163	44	469	1.31	89	252	63	921	1.32 ^a	73 ^a	211	55	1.35
	10	158	58	151	45	471	1.30	94	261	67	935	1.47 ^{ab}	76 ^{ab}	204	56	1.37
	15	161	60	152	43	461	1.40	95	260	65	915	1.50 ^b	77 ^b	205	54	1.44
	SEM	3.50	0.96	4.92	1.12	8.16	0.046	1.38	6.65	1.03	11.10	0.032	0.68	4.42	0.84	0.025
Significance																
Strain		**	ns	ns	ns	ns	ns	ns	ns	**	**	ns	*	ns	ns	ns
Pepper		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	*	ns	ns	ns
Strain x Pepper		ns	ns	ns	ns	ns	ns	*	ns	ns	ns	ns	**	ns	ns	ns

BW_8 body weight at 8 days of age, BW_{18} body weight at 18 days of age, WG_{8-18} body weight gain from 8 to 18 days, WC_{8-18} water consumption from 8 to 18 days, FC_{8-18} feed consumption from 8 to 18 days, FCR_{8-18} feed conversion ratio from 8 to 18 days, g gram, g/b/d gram per bird per day, gf/gg gram feed/gram gain; * $P < 0.05$, ** $P < 0.01$, ns not significant; ^{a, b} means with different superscripts significantly differ at $P < 0.05$.

4. Conclusions and Recommendations

We investigated the effect of hot red pepper (*Capsicum annuum*) as an antioxidant on the growth performance of broilers during the starter phase. The results show that broiler strain and dietary inclusion levels of hot red pepper influence growth performance during the starter period. Ross 308 consistently outperformed Cobb 500 in terms of body weight and weight gain, particularly during the later stages of

the starter period. Based on the observed results, supplementing hot red pepper at 15g/L enhanced weight gain and growth performance in Ross 308. The feed conversion ratio was not significantly affected by strain and pepper, although feed consumption was slightly higher in Ross 308. These findings align with the existing literature that positions Ross 308 as a fast-growing strain with efficient feed utilization. Ross 308 was more responsive to red hot pepper bioactive compounds (capsaicin). Furthermore, significant interactions between strain and pepper level were observed for feed consumption and weight gain, indicating that the response to dietary pepper may be strain-dependent. The inclusion of 15 g/L HRP for Ross 308 will benefit small-scale farmers, as birds will reach the targeted market weight earlier due to its rapid growth rate, resulting in savings on feeding costs and improved economic sustainability. This is key because small-scale broiler farmers often sell live birds.

Future investigations on the inclusion of pepper in water should cover several strains, extend to broilers reaching market weights (up to 42 days), and assess the effects on gut histomorphology and microbiota, enzyme activities, haematology, and meat quality, in addition to growth performance.

Study Limitations

The findings of this study apply to the starter phase of broiler production. Two broiler strains (Ross 308 and Cobb 500) were used in this study, resulting in conclusions that are limited to these strains. Generalisation to other broiler strains could be based on initial weight classification (lighter and heavier strains at day old). Therefore, a cautious comparison of the study's findings with the existing literature is necessary.

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Declaration of Interest Statement

The authors declare that they have no conflict of interests.

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