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Research Article
Effect of Dietary Combinations of Garlic and Onion in Broiler Production

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Abstract

Objective: The goal of the present study was to evaluate the effect of dietary supplementation of garlic and onion in the diet of broiler chickens. The chickens were assessed with regard to feeding, growth performance and behavioral responses. **Methodology:** Fifty 1-day-old Ross 308 broilers were randomly assigned to two experimental dietary groups. Each treatment included 5 replicates with five birds in each replicate. The experimental groups included a control group with a basal diet containing neither garlic nor onion. The remaining group received the basal diet plus 2.5 kg t^{-1} garlic and 2.5% onion powder at room temperature between 30-35°C at a relative humidity of 15-20%. Feed intake and body weight were measured once each week. For measurement of the carcass, organ weights and blood analysis, one bird per pen was euthanized at a rate of 42 birds per day. **Results:** Present investigation showed that the combination of garlic and onion improved chicken performance and decreased blood cholesterol, triglycerides and low-density lipoproteins. Behavioral observations showed higher feeding and drinking activities when garlic and onion were provided. **Conclusion:** The addition of garlic and onion improves the feeding efficiency and body weight of treated chickens.

Key words: Garlic, onion, broiler, production, behavior

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Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The desert is the most prominent feature of Saudi Arabia, significantly more than one-half of the area of Saudi Arabia is desert and the average summer temperature varies between 45 and 54°C[1]. The high temperature and an increase in solar radiation characterize the desert environment during the day, especially during the summer. Animal production in Saudi Arabia suffers from a scarcity of food and water resources, overgrazing, deterioration of rangelands, desert environmental conditions and diminished quality of veterinary services, resulting in a decrease in the livestock population[1,2]. As climate change occurs as a result of carbon dioxide emissions, it is vital to find ways to counteract the adverse effects of heat stress in food-producing animals such as broilers. Excessive heat stress may cause hyperthermia and potentially have several physiological side effects and economic impacts on the poultry industry[1,2]. These include abnormal reproductive function, oxidative stress, enzymatic dysfunction, electrolyte imbalances, reduced meat quality and eventually, severe economic losses. These occur as a result of increased mortality and decreased overall animal performance[3]. When the birds are exposed to heat stress, they use several heat-regulating mechanisms to reduce heat gain by an equivalent loss, maintain their core body temperature and reach thermal equilibrium. Numerous studies have considered the adverse effects of heat stress on the immune response[4], feed and water intake[5,6], weight gain[7] and increased mortality rates among broilers[8,9]. Previous studies showed that heat-stressed birds spend less time feeding, moving or walking and more time drinking, panting, elevating wings and resting[9,10]. Accordingly, it has become necessary to develop alternative strategies for animal growth promotion under heat stress conditions. There are a number of components that can be added to the feed or drinking water of a poultry flock to improve bird production or to reduce the impact of heat stress. Garlic (*Allium sativum*) and onion (*Allium cepa*) are used widely for human food and medicinal applications. These compounds, recently referred to as "nutraceuticals" or "phytochemicals" are classified as non-essential micronutrients and can contribute to human homeostasis, playing a role in preserving health[11]. Extracts from garlic and onion have been reported to be useful in cardiovascular disease because of their hypocholesterolemic, hypolipidemic, antihypertensive, antidiabetic, antithrombotic and antihyperhomocysteinemic effects[12]. Garlic and onion possess many other biological qualities including antimicrobial, antioxidant, anticarcinogenic, antimutagenic, antiasthmatic, immunomodulatory and prebiotic activities playing a role in the maintenance of health[12]. Several studies have been conducted by adding either onion or garlic as a powder to livestock feed as a growth promoter[13] or as an anticoccidial[14], antibacterial[15], hypocholesterolemic or hypolipidemic agent[16]. Contrary to these studies, there has been a deficiency of information on the combined effect of garlic and onion on chicken performance and carcass characteristics. It is proposed that a combination of garlic and onion will improve broiler production and physiological and behavioral responses compared to control groups. Therefore, this experiment was conducted to examine the effect of a combination of garlic and onion on growth yield and carcass traits in broilers when used as a powder.

MATERIALS AND METHODS

Birds and management: An experiment was conducted at the Al-Ghaith farm station in the Tayma region of the Tabuk Governate, Saudi Arabia. The care and use of experimental animals complied with local animal welfare laws, guidelines and policies. Fifty 1-day-old Ross 308 broilers were obtained from a commercial hatchery in the Tabuk Governate, Saudi Arabia. The birds were assigned randomly to two experimental groups. Each treatment involved 5 replicates with five birds in each replicate. The experimental groups included a control group with a regular diet used in broiler feeding (Table 1). The remaining group received an additional combination of 5 kg t^{-1} garlic and onion powder (2.5 kg t^{-1} each) in the regular diet. The birds were fed a starter diet (CP: 21.5%, ME: 2900 kcal) from 0-21 days and finisher diet (CP: 20.0%, ME: 3100 kcal) from day 22-42 (Table 1). The birds were raised in pens (200×200×100 cm) for 6 weeks, including free access to water and feed throughout the experimental period that lasted until 42 days. The photoperiod consisted of 23 h of light and 1 h of darkness. The ambient temperature varied between 30-35°C and the relative humidity was 15-20%. On day 14 of the experiment, a combination of garlic and onion was offered based on previous results obtained from diet studies. Garlic and onion were provided exclusively to the broilers. During the entire experimental period, both groups used no medications.

Performance traits: Feed intake, body weight (Table 2) and weight change were determined once each week on a per cage basis and bird mortality was recorded as it occurred.

Carcass traits: At 42 days of age, one bird per replicate was randomly euthanized by cutting the carotid arteries. The

Table 1: Composition of basal starter and finisher diets

Items		Starter	Finisher
Ingredient (g kg^{-1})	Corn	505.1	524.6
	Soybean meal	385.0	350.0
	Soybean oil	35.8	59.0
	Monocalcium phosphate	14.2	10.0
	$CaCO_3$	17.3	16.7
	NaCl	3.1	2.1
	$NaHCO_3$	2.0	1.6
	Trace mineral premix	2.5	2.5
	Vitamin premix	2.5	2.5
	DL-methionine	2.5	1.0
	Sand	30.0	30.0
Calculated nutrient compostion	Metabolizable energy (kcal kg^{-1})	2900.0	3100.0
	Crude protein (g kg^{-1})	215.0	200.0

Table 2: Average (Mean±SE) body weight (g/bird) when supplementary garlic and onion extract were added to the feed (2.5 kg t^{-1} each)*

Age (weeks)	Control	Garlic and onion additives	SE**	p-value
First	157.96[a]	162.88[a]	10.96	1.00
Second	363.39[a]	365.82[a]	10.96	1.00
Third	674.42[a]	682.70[a]	10.96	1.00
Fourth	1006.26[b]	1098.83[a]	10.96	<0.01
Fifth	1355.42[b]	1493.90[a]	10.96	<0.01
Sixth	2010.53[b]	2095.68[a]	10.96	<0.01

*[a,b]Values within a row with different superscripts differ significantly at p<0.05, **SE: Standard error

carcass and abdominal fat were weighed and the dressing percentage was calculated. The carcass yield was calculated by dividing the eviscerated weight by the live weight and the dressing percentage was calculated as follows:

$$\text{Dressing percentage} = \frac{\text{Carcass weight}}{\text{Live weight}} \times 100$$

Behavioral data: Live observations of the birds' behavior were carried out three times daily at 09:00, 13:00 and 17:00 h using instantaneous scan sampling at 15 min intervals h^{-1}. The number of birds in each cage performing the activities of drinking, feeding, standing, sitting, running, peering, panting and wing spreading were recorded. Chickens were monitored daily for their clinical health condition and a veterinarian diagnosed any health disorders. Observer(s) counted the number of birds in each cage performing each activity (drinking, feeding, preening, standing, sitting, running, panting and wing spreading) every 15 min during the observation periods.

Statistical analysis: A randomized design was employed. Authors subjected the data collected relative to the age of the birds to one-way ANOVA with repeated measures using the mixed model procedure of the SAS Institute[17]. In the model, the performance and behavioral traits of the birds were included as dependent variables. The independent fixed effects consisted of the impact of the treatment (control or garlic and onion supplements), the age of the birds and the particular interaction. The birds were included as a random effect as follows:

$$Y_{ijk} = \mu + T_i + A_j + TA_{ij} + e_{ijk}$$

Where:

- Y_{ijk} = Observational value (performance traits or behavioral traits)
- μ = Overall mean
- T_i = Effect of the treatment (control vs. garlic and onion supplements)
- A_j = Effect of the bird's age (weeks)
- TA_{ij} = Effect of the interaction between treatment and age
- e_{ijk} = Residual error

The Tukey-Kramer test was used to identify the mean differences between the different treatments. Differences were considered significant with p<0.05. All values were presented as the least squares means±standard error unless otherwise mentioned.

RESULTS

Performance traits: The results of the current investigation showed that using a combination of garlic and onion in poultry diet significantly improved nutritional performance from weeks 4-6.

Feed intake did not show any significant difference during the first 2 weeks since there were no additives for both

Table 3: Average (Mean±SE) feed intake (g/bird) when supplementary garlic and onion extract were added to the feed (2.5 kg t^{-1} each)*

Age (weeks)	Control	Garlic and onion additives	SE**	p-value
First	135.56[a]	139.54[a]	21.56	1.00
Second	261.94[a]	262.90[a]	21.56	1.00
Third	515.46[b]	661.40[a]	21.56	<0.01
Fourth	738.60[a]	712.40[b]	21.56	0.10
Fifth	794.20[b]	936.20[a]	21.56	<0.01
Sixth	1056.40[b]	1250.40[a]	21.56	<0.01

*[a,b]Values within a row with different superscripts differ significantly at p<0.05, **SE: Standard error

Table 4: Average (Mean±SE) live weight, carcass weight (g/bird) and internal viscera (% of live weight) when supplementary garlic and onion were added to the feed (2.5 kg t^{-1} each)*

Variable (g)	Control	Garlic and onion additives	SE**	p-value
Live weight	2021.66[b]	2126.10[a]	23.92	0.02
Carcass weight	1476.89[b]	1578.30[a]	16.75	<0.01
Chest weight	34.85[a]	35.711[a]	0.33	0.10
Thigh weight	32.32[a]	31.61[a]	0.40	0.25
Back weight	13.48[a]	13.83[a]	0.27	0.39
Wing weight	10.87[a]	11.19[a]	0.26	0.41
Neck weight	5.71[a]	5.92[a]	0.19	0.45
Abdominal fat weight	4.72[a]	2.62[b]	0.63	0.05
Liver weight	3.18[b]	3.44[a]	0.07	0.03

*[a,b]Values within a row with different superscripts differ significantly at p<0.05, **SE: Standard error

Table 5: Average (Mean±SE) blood cholesterol, albumin, triglyceride, HDL and LDL levels when supplementary garlic and onion were added to the feed (2.5 kg t^{-1} each)*

Variable (mg dL^{-1})	Control	Garlic and onion additives	SE**	p-value
Blood cholesterol	280.80[a]	205.34[b]	24.72	<0.01
Blood albumin	5.30[a]	4.82[b]	0.27	<0.01
Blood triglycerides	176.00[a]	140.76[b]	12.80	<0.01
HDL	132.68[a]	165.48[a]	1.72	<0.01
LDL	169.97[a]	78.52[b]	23.66	0.01

*[a,b]Values within a row with different superscripts differ significantly at p<0.05, LDL: Low-density lipoprotein, HDL: High-density lipoprotein, **SE: Standard error

groups, however, during the 3rd week, the birds fed a diet supplemented with extra garlic and onion showed a higher feed intake compared to the control group. Significant differences during the 5th and 6th weeks of the experiment were also observed, as shown in Table 3.

Carcass traits: A higher body weight resulted in higher carcass and eviscerated yields when garlic and onion was added, as shown in Table 3. There were no significant differences in the chest, thigh, back, wings and neck weights relative to the live body weight in both groups. Nevertheless, there was a significant decrease in the percentage of abdominal fat weight when garlic and onion were offered compared to the control group. The liver weight increased significantly in the treated group compared to the controls (Table 4).

The effects of a dietary combination of garlic and onion on blood cholesterol, albumin triglycerides, high-density lipoprotein (HDL) and low-density lipoprotein (LDL) are shown in Table 5. There was a significant decrease in the blood cholesterol, albumin, triglycerides and LDL when a combination of garlic and onion was added to the chicken ration (p<0.01). In contrast, when garlic and onion were provided, the HDL increased compared to the control group.

Behavioral data: Behavioral observations showed that the chickens fed with extra garlic and onion visited the feed and water trough more frequently than the control group (Table 6). Furthermore, their wing spreading and standing activity were higher than the control group, which showed higher sitting and running activities. There were no significant differences in the other behavioral activities between the experimental and control groups.

DISCUSSION

In broiler production, higher body weight within the shortest time was achieved. Therefore, manipulation of

Table 6: Average (Mean±SE) bird behavior (N/day) when supplementary garlic and onion were added to the feed (2.5 kg t^{-1} each)*

Activity (N/day)	Control	Garlic and onion additives	SE**	p-value
Eating	2.30[b]	3.45[a]	0.12	<0.01
Drinking	1.55[b]	1.63[a]	0.07	<0.01
Sitting	0.09[a]	0.03[b]	0.02	<0.01
Standing	3.32[b]	4.97[a]	0.08	<0.01
Running	0.017[a]	0.001[b]	0.005	<0.01
Peering	0.02[b]	0.03[a]	0.02	0.20
Wingspread	3.05[b]	4.97[a]	0.04	<0.01
Panting	0.02[a]	0.03[a]	0.02	0.27

*[a,b]Values within a row with different superscripts differ significantly at p<0.05, **SE: Standard error

genetic performance, feed composition or addition of extra materials would be of great benefit to farmers. Similarly, an additional benefit would be gained by the provision of additional ingredients that prevent heart disease due to their hypocholesterolemic, hypolipidemic, antihypertensive, antidiabetic, antithrombotic and antihyperhomocysteinemic effects. Additional ingredients that possess many other biological qualities such as antimicrobial, antioxidant, anticancer, antimutagenic, antiasthmatic, immunomodulatory and prebiotic activity would be favorable for human meat consumers[12]. Garlic and onion have several beneficial effects on both humans and animals including antimicrobial, antioxidant and antihypertensive properties[18]. These properties are associated with bioactive components that exist in plants[18]. The primary sulfur-containing ingredients in both garlic and onion are alliin, allicin and lipid soluble sulfur compounds, such as diallyl sulfide and diallyl disulfide. Additional sulfur compounds provide garlic and onion with their characteristic odor and flavor and most of their biological properties[11,12,19]. The biological effects of additional constituents of garlic and onion, such as lectins (the most abundant proteins in garlic and onion), cysteine and methionine (an abundant amino acid), improve the growth performance of chicks[12]. Parallel to present study results, Al-Ramamneh *et al.*[14] showed an improvement in body weight when adding 5% onion powder to broiler rations. It has been reported that onion stimulates the digestive process, accelerating digestion and reducing food transit time in the gastrointestinal tract[20]. Therefore, present study showed that a combination of garlic and onion improves the growth performance of chickens possibly as a result of the content of organosulfur compounds. Similarly, Aji *et al.*[21] reported that a diet containing fresh onion had a positive influence on the body weight/feed conversion ratio of broilers compared to a diet without onion. In contrast, Karangiya *et al.*[22] found that a diet of garlic and ginger improved body weight gain in broilers but showed no significant effects on feed intake. Garlic and onion contain organic sulfur compounds including S-methylcysteine sulfoxide and S-allylcysteine sulfoxide with antioxidant and antiperoxide activity[12]. These compounds are related to a decrease in blood lipid, liver protein and glucose[23,24]. Therefore, in present investigation, the possible combination of garlic and onion has lipotropic effects that affect lipid metabolism through fatty acid transport. This can increase lipid utilization and decrease abdominal fat. Goodarzi *et al.*[16] reported that the use of onion bulbs in the broiler diet can lower triglycerides and total cholesterol in blood serum. Allicin and its derivative compounds are the primary active substances responsible for the hypolipidemic and hypocholesterolemic effects of onion and garlic[12,25]. These compounds possibly impact hypocholesterolemia by inhibiting hepatic cholesterol biosynthesis, enhancing cholesterol turnover to bile acids[26] or inhibiting cholesterol absorption from the intestinal lumen[27]. Observations confirmed a correlation between higher feed intake and greater eating and drinking activity in birds on the garlic and onion diet compared to the control group. The birds showed no signs of heat stress during the entire experimental period, since no signs of panting were observed in both groups. Heat-stressed birds stand infrequently, sit, pant and spread their wings away from the body to promote cooling by reducing body insulation[10]. A diet of garlic and onion may aid in absorbing excessive heat in the broiler body due to antioxidants that can neutralize cellular damage that results from heat exposure and lower the body temperature to average levels[28]. The results indicate that incorporation of garlic and onion in the broiler diet significantly enhanced the growth and economic and productive performance of broiler chicks. The physiological measurements (body weight, weight gain, feed intake, carcass weight and internal organ weights) improved more significantly in chickens treated with an onion diet compared to the control group under the same rearing conditions. This results from their full range of critical biological activities. The results showed a low mortality rate in birds fed garlic and onion compared to the control group. Therefore, the addition of garlic and onion as a

dietary growth promoter reduces the costs of production through improved feeding efficiency, weight gain and disease tolerance.

CONCLUSION

It is concluded that the addition of garlic and onion improves the feeding efficiency and body weight of treated chickens.

SIGNIFICANCE STATEMENT

This study showed that incorporating garlic and onion in the broiler diet improved chicken performance and decreased cholesterol, triglycerides and low-density lipoprotein. The behavioral observations of these birds showed higher feeding activity. A garlic and onion diet can serve as an important and beneficial probiotic that improves meat production in broilers by altering drinking activity. This study will help researchers to better understand the use of feed additives as opposed to the use of antibiotics that remain poorly understood. Thus, a new theory of feed additives has developed.

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