Effect of feeding cinnamon and garlic as an alternative to antibiotic on growth performance and carcass characteristics in broiler

M Akter[1]*, M Asaduzzaman[2] and FY Sumi[1]

[1]Department of Animal Nutrition, Genetics and Breeding, Sher-e-Bangla Agricultural University, Dhaka
[2]Department of Dairy Science, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh

*Correspondence: makter.angb@sau.edu.bd

ABSTRACT

The experiment was conducted to evaluate the potential of feeding cinnamon and garlic on growth performance, carcass yield and immune parameters in commercial broiler. A total of 225 one-day-old Lohman meat (Indian river) broiler chicks have an average body weight of 40±0.50 g were divided into 5 dietary treatment groups. The treatments were T_0= control (basal feed), T_1= basal feed + antibiotic, T_2= basal feed + 0.2% cinnamon, T_3= basal feed + 0.2% garlic and T_4= basal feed + 0.2% cinnamon + 0.2% garlic. The average live weight and body weight gain were significantly ($P<0.05$) increased in the 0.2% cinnamon + 0.2% garlic treated group compared with others. Improved FCR was observed in birds fed a combined addition of 0.2% cinnamon and 0.2% garlic with the basal diet than the other treatment groups. All the supplemented group significantly increased the proportion of breast meat compared to control, while wing and back meat was higher in the T_2, T_3 and T_4 supplemented group compared to T_0 and T_1 group ($P<0.05$). Dietary supplementation of T_2, T_3 and T_4 also increased the weight of liver, heart, neck, gizzard and giblet ($P<0.05$). Dietary supplementation of T_1, T_2, T_3 and T_4 significantly reduced the concentration of blood WBC and Granulocyte. Taken together, it can be concluded that the use of 0.2% cinnamon and 0.2% garlic in broiler diet separately or combined resulted in improved growth performance, carcass yields, and immunity in broiler chickens and therefore can be recommended as alternatives to antibiotics.

Keywords: Cinnamon, garlic, growth performance, broiler, antibiotic alternatives

INTRODUCTION

Sub-clinical application of in-feed antibiotics in animal diets has appeared as a controversial issue worldwide and is facing reduced social acceptance due to the emergence of residues and resistant strains of bacteria. Scientific evidence recommends that the massive use of these compounds has led to increased the problem of antibiotic resistance (Forgetta et al., 2012; Furtula et al., 2010), and the presence of antibiotics residues in feed and environment (Carvalho and Santos, 2016; Gonzalez Ronquillo and Angeles Hernandez, 2017), compromises human and animal health (Diarra et al., 2010). As a results new alternatives are being investigated for livestock producers, among which phytogenic and herbal products have been given considerable awareness as possible in-feed antibiotics substitutions. Beneficial effects of bioactive plant substances in animal nutrition may include the stimulation of appetite and feed intake, the improvement of endogenous digestive enzyme secretion, activation of immune responses and antibacterial, antiviral and antioxidant actions.

Cinnamon (*Cinnamomum zeylanicum*) commonly known as “dalchini” is one of the earliest medicinal plants, widely used as condiments in India and indigenous to Sri Lanka and South

India (Jakhetia et al., 2010). The principal chemical components of cinnamon are cinnamaldehyde, trans-cinnamaldehyde (Cin) and eugenol, which are present in the essential oil and contribute to the fragrance and various biological activities (Chang et al., 2013). Studies have revealed that cinnamon possesses appetite and digestion-stimulant properties, anti-bacterial properties (Chang et al., 2001), antioxidant properties and other medicinal properties like anti-ulcer, anti-diabetic, anti-inflammatory (Jakhetia et al., 2010). Cinnamon (*Cinnamomum cassia*) is known as an appetite and digestion stimulant and its antimicrobial properties are mainly related to its cinnamaldehyde content followed by eugenol and carvacrol (Tabak et al., 1999). Cinnamaldehyde and eugenol have been indicated to possess antibacterial activity against a wide range of bacteria (Chang et al., 2001), antioxidant properties (Gurdip et al., 2007) and inhibitory properties against *Aspergillus flavus* (Montes-Belmont and Carvajal, 1998). Recent studies have also observed that cinnamon powder, cinnamaldehyde alone or in combination with other essential oils had a wide line-up of beneficial effects in poultry. Some of those effects include increased feed intake, improved performance, feed efficiency and health status, increased breast meat yield (Al-Kassie, 2009), increased pancreatic and intestinal lipase activity (Kim et al., 2010), improved growth performance and meat quality (Sang-Oh et al., 2013), protection against pathogens such as *Escherichia coli*, *Pseudomonas aeruginosa*, *Enterococus faecalis*, *Staphylococcus aureus*, *Staphylococcus epidermis*, *Salmonella sp.*, *Helicobacter pylori* and *Parahemolyticus* (Chang et al., 2001).

Garlic (*Allium sativum*) is an issue of considerable interest as a medicine and therapeutic agent worldwide since ancient times. The main pharmacological effects of garlic are ascribed to its organosulphur compounds (Tapiero et al., 2004). Freshly crushed garlic contains allicin, alliin, ajoene, diallylsulfide, dithiin, S- allylcysteine. Garlic as an accepted feed additive in poultry nutrition may be of great advantage and importance particularly for broiler growers. This is outstanding to their antibacterial, anti-inflammatory, antiseptic, anti-parasitic and immunomodulatory properties of garlic. In vitro studies have discovered that garlic has antibacterial, antifungal, antiparasitic, antiviral (Ankri and Mirelman, 1999), antioxidant (Prasad et al., 1995), as well as antithrombotic, vasodilatory and anticancer (Agarwal, 1996) activities. It has benefits in lowering total plasma cholesterol, reducing blood pressure and decreasing platelet aggregation (Sterling and Eagling, 2001). Additionally, garlic is exact rich in aromatic oils, which upsurge digestion and positively influenced respiratory system being breathe in into air sacs and lungs of birds. Also, it was found that garlic has resilient antioxidative properties (Gardzielewska et al., 2003).

A number of studies have been conducted to examine the consequence of garlic (Demir et al., 2003; Kim et al., 2009) and cinnamon powder (Chen et al., 2008a, 2008b; Park, 2008) on broiler performance and meat quality but the results have not been compatible. Moreover, research on the combined use of cinnamon and garlic in performance of broiler production is still limited in Bangladesh. We hypothesized that cinnamon and garlic can assure as alternatives for antibiotics as pressure to eliminate growth promotant antibiotic use increases in Bangladesh. Thus, this study designed at assessing the potential of feeding of cinnamon

and garlic as antibiotic alternative on growth performance and immune responses in broilers.

MATERIALS AND METHODS

The research work was conducted at Sher-e-Bangla Agricultural University, Poultry Farm, Dhaka, with 225 one-day-old chicks for a period of 28 days from 27th July to 23th August, 2022 to investigate the separate and combined effect of cinnamon and garlic on growth performance, carcass traits and immune parameters of commercial broiler.

Preparation of experimental house

The broiler shed was an open-sided house with a concrete floor. The experimental room was properly cleaned and washed by using tap water. All the equipment of the broiler house was cleaned and disinfected. The house was disinfected by n-alkyl dimethyl benzyl ammonium chloride (TimsenTM) solution before starting the experiment. After proper drying, the house was divided into pens as per the layout of the experiment by polythene sheet so that air cannot pass from one pen to another. Before placement of chicks, the house was fumigated by formalin and potassium permanganate @ 500 ml formalin and 250 g potassium permanganate (i.e. 2:1) for 35 m^3 experimental area. Fresh, clean and sun-dried rice husk was used as shallow litter to absorb moisture from fecal discharge of broiler chicken. About 250 g calcium oxide powder was mixed with rice husk in every pen as disinfectant. Electric brooder was used to brood chicks. Brooding temperature was adjusted (below 35° C) with house temperature. Electric fans were used as per necessity to save the birds from the heat stress. The brooding temperature was checked every 2 hours later by digital thermometer to maintain the temperature of the brooder. Due to wire-net cross ventilation was easy to remove polluted gases from the farm. Daily room temperature (℃) and humidity were recorded with a digital thermo-hygrometer.

Experimental layout, birds and dietary treatments

A total of 225 one-day-old broiler chicks were divided into 5 experimental groups with 3 replications of 15 chicks each using a completely randomized block design. Experimental layout is presented in Table 1. The "Lohman Meat (Indian River)" strain having 40.00±0.50 g average body weight was purchased from Kazi farm limited hatchery, Gazipur, Dhaka. Starter and grower commercial Kazi broiler feed were procured from the local market. Feed was supplied 4 times daily by following Indian River Management Manual and *ad libitum* drinking water 2 times daily. The composition of the starter and grower diet which was collected from Kazi farm limited company is given in Table 2.

Experimental materials

The collected chicks were transferred to the university poultry farm and held in electric brooders similarly for 7 days by retaining standard brooding protocol. During brooding time only basal diet was given, no cinnamon/garlic was used as treatment. The chicks were supplied glucose water with vitamin-C to drink for the first 3 hours to overcome dehydration and transportation stress. Subsequently small feed particles were supplied on the newspapers

to start feeding for the first 24 hours. After seven days, chicks from brooders were distributed randomly in dietary treatments. The birds were vaccinated on the proper schedule against new castle disease, infectious bronchitis and infectious bursal disease (Table 3). Vitamin-B complex, vitamin-A, D_3, and E were used against deficiency diseases. Electromin and Vitamin-C also used to save the birds from heat stress. After 28 days of nursing and feeding, data were collected for the following parameters: feed intake, live weight, body weight gain, feed conversion ratio, carcass characteristics, and total blood count.

Collection of cinnamon and garlic powder

The cinnamon and garlic powder of Pran Company were purchased from Super shop. The cinnamon and garlic powder were supplied to the birds after mixing with feed according to the desired treatments.

Recorded parameters

Weekly live weight, weekly feed intake and death of chicks to calculate mortality percent were taken during the experimental period. FCR was calculated from final live weight and total feed consumption per bird in each replication. After slaughter carcass weight and gizzard, liver, spleen, bursa, intestine and heart were measured from each broiler chicken. The dressing yield was calculated for each replication to find out the dressing percentage.

At the end of the experiment, blood sample was collected randomly from each replication of every treatment. About 2mL blood was collected from wing vein with syringe in a vacutainer. Vacutainer contains EDTA solution which prevents blood coagulants. Few hours after collection the blood sample was tested by Auto Blood Analyzer in the laboratory.

Statistical analysis

Total data were compiled, tabulated and analyzed according to the objectives of the study. Excel Program was practiced for preliminary data calculation. The collected data was subjected to statistical analysis by applying one way ANOVA using Statistical Package for Social Sciences (SPSS version 16.0). Differences between means were tested using Duncan's multiple comparison test, LSD and significance was set at $P<0.05$.

RESULTS AND DISCUSSION

The research work was accompanied to investigate the effect of feeding cinnamon and garlic on growth performance of commercial broiler. The production performances of broiler chicken were evaluated by average live weight, average feed consumption (FC), weekly feed consumption, feed conversion ratio (FCR), average body weight gain, weekly body weight gain and survivability of birds. Carcass characteristics were taken by dressing percentage (DP), carcass weight and relative weight of giblet organs. The results of this research work are given and discussed below:

Table 1. Layout of the experiment

Treatments	Arrangement of treatments	Replications			Total number of birds
		1	2	3	
T_0	Basal feed (ready-made feed)	15	15	15	45
T_1	Basal feed + Antibiotic	15	15	15	45
T_2	Basal feed + 0.2% Cinnamon	15	15	15	45
T_3	Basal feed + 0.2% Garlic	15	15	15	45
T_4	Basal Feed + 0.2% Cinnamon + 0.2% Garlic	15	15	15	45
Total					**225**

Table 2. Chemical composition of the basal diet (starter and grower)

Parameter	Starter diet (0-7 days)	Grower diet (8-28 days)
Protein (%)	21.0	19.0
Fat (%)	6.0	6.0
Fiber (%)	5.0	5.0
Ash (%)	8.0	8.0
Lysine (%)	1.20	1.10
Methionine (%)	0.49	0.47
Cysteine (%)	0.40	0.39
Tryptophan (%)	0.19	0.18
Threonine (%)	0.79	0.75
Arginine (%)	1.26	1.18

Table 3. The vaccination schedule

Age of birds	Vaccine	Name of vaccine	Route of administration
2 days	Infectious Bronchitis+ Newcastle Disease	CEVAC BIL Vaccine	One drop in one eye
9 days	Gumboro	CEVAC IBD L Vaccine	One drop in one eye
16 days	Gumboro	CEVAC IBD L Vaccine	Drinking water
19 days	Newcastle Disease	CEVAC NEW L Vaccine	Drinking water

Table 4. Effects of Cinnamon and Garlic on growth performances of broiler chicken

Treatments	Average Live Weight (g/bird)	Average BWG (g/bird)	Average FI (g/bird)	Final FCR	Dressing (%)	Survivability (%)
T_0	1942.67^{bd}±0.32	1902.67^{c}±0.33	2549.58±1.00	1.34±0.012	72.57±0.20	100.00±0.00
T_1	1947.33^{bd}±0.40	1907.33^{c}±0.41	2550.00±0.30	1.34±0.020	74.87±0.10	95.56±0.50
T_2	1987.33^{bc}±0.07	1947.33^{b}±0.07	2589.95±0.50	1.33±0.030	75.95±0.06	100.00±0.00
T_3	1979.00^{b}±0.72	1939.00^{bc}±0.73	2578.87±0.80	1.33±0.031	75.99±0.32	100.00±0.00
T_4	2085.00^{a}±1.59	2045.00^{a}±1.60	2678.95±0.50	1.31±0.020	76.21±0.24	100.00±0.00
Level of Significance	*	*	NS	NS	NS	NS

Here, T_0 = Control (basal feed), T_1 = Basal feed + Antibiotic, T_2 = Basal feed + 0.2% Cinnamon, T_3 = Basal feed + 0.2% Garlic, and T_4 = Basal feed + 0.2% Cinnamon + 0.2% Garlic. Values are mean ± SE (n=45) one way ANOVA (SPSS, Duncan method). * Significant difference ($P<0.05$). NS: Non-significant. SE= Standard Error. ^{abcd}: Values bearing different letters within each column differ significantly.

Table 5. Effects of Cinnamon and Garlic on carcass characteristics of broiler chickens

Treatments	Breast (g)	Thigh (g)	Wing (g)	Drumstick (g)	Back (g)
T_0	400.50^{d}±1.00	96.00±2.33	90.86^{b}±2.00	75.55±0.40	210.00^{c}±2.00
T_1	476.77^{c}±2.50	95.50±1.09	95.25^{b}±0.40	75.60±1.64	208.70^{c}±1.80
T_2	490.50^{b}±1.50	100.86±1.00	127.75^{a}±0.90	77.80±0.75	230.55^{b}±0.50
T_3	500.30^{b}±1.17	102.50±0.80	129.50^{a}±1.70	80.70±0.78	245.00^{b}±1.00
T_4	550.80^{a}±1.40	110.90±0.83	140.30^{a}±1.70	87.00±0.50	290.80^{a}±1.77
Level of significance	*	NS	*	NS	*

Here, T_0 = Control (basal feed), T_1 = Basal feed + Antibiotic, T_2 = Basal feed + 0.2% Cinnamon, T_3 = Basal feed + 0.2% Garlic, and T_4 = Basal feed + 0.2% Cinnamon + 0.2% Garlic. Values are mean ± SE (n=45) one way ANOVA (SPSS, Duncan method). * Significant difference (P<0.05). NS: Non-significant. SE= Standard Error. ^{abcd}: Values bearing different letters within each column differ significantly.

Table 6. Effects of Cinnamon and Garlic on internal organs of broiler chickens under different treatment groups

Treat-ment	Liver (g/bird)	Heart (g/bird)	Neck (g/bird)	Gizzard (g/bird)	Giblet (g/bird)	Intestine (g/bird)	Spleen (g/bird)	Bursa (g/bird)
T_0	45.70^{c}±0.70	9.50^{b}±0.55	40.80^{c}±3.30	25.14^{b}±0.14	121.14^{c}± 1.00	128.30±0.40	2.00±0.20	2.00±0.70
T_1	45.55^{c}±1.00	9.75^{b}±0.30	41.00^{c}±1.07	28.85^{b}±1.20	125.15^{c}±0.78	130.00±1.00	2.20±0.20	2.10±0.30
T_2	49.50^{bc}±0.50	11.00^{a}±0.70	44.50^{b}±5.51	40.15^{a}±0.40	145.15^{b}±0.40	120.50±1.30	2.05±0.40	2.10±0.46
T_3	51.55^{ab}±1.20	11.70^{a}±0.40	45.38^{b}±3.70	42.10^{a}±0.70	150.73^{ab}±0.87	122.00±0.55	2.22±0.30	2.15±0.70
T_4	59.80^{a}±0.60	12.80^{a}±0.25	48.90^{a}±1.77	45.20^{a}±2.00	166.70^{a}±1.30	126.55±1.50	2.28±0.40	2.10±0.44
Level of significance	*	*	*	*	*	NS	NS	NS

Here, T_0 = Control (basal feed), T_1 = Basal feed + Antibiotic, T_2 = Basal feed + 0.2% Cinnamon, T_3 = Basal feed + 0.2% Garlic, and T_4 = Basal feed + 0.2% Cinnamon + 0.2% Garlic. Values are mean ± SE (n=45) one way ANOVA (SPSS, Duncan method). * Significant difference (P<0.05). NS: Non-significant. SE= Standard Error. ^{abc}: Values bearing different letters within each column differ significantly.

Table 7. Effects of Cinnamon and Garlic on immune parameters of broiler chicken under different treatment groups

Treatment	WBC ($x10^9$/L)	Lymphocyte($x10^9$/L)	Granulocyte($x10^9$/L)
T_0	16.50^{a}±0.11	2.00^{abc}±0.19	11.20^{a}±0.10
T_1	9.00^{b}±0.45	2.50^{a}±0.25	4.11^{b}±0.20
T_2	9.00^{c}±0.20	3.00^{a}±0.20	7.00^{c}±0.10
T_3	9.50^{c}±0.22	2.66^{b}±0.10	7.70^{d}±0.14
T_4	5.00^{d}±0.10	2.05^{c}±0.13	3.50^{e}±0.10
Level of significance	*	*	*

Here, T_0 = Control (basal feed), T_1 = Basal feed + Antibiotic, T_2 = Basal feed + 0.2% Cinnamon, T_3 = Basal feed + 0.2% Garlic, and T_4 = Basal feed + 0.2% Cinnamon + 0.2% Garlic. Values are mean ± SE (n=45) one way ANOVA (SPSS, Duncan method). * Significant difference (P<0.05). SE= Standard Error. abcde: Values bearing different letters within each column differ significantly.

Growth performance

Average live weight

The data presented in Table 4 showed the effect of cinnamon and garlic on growth performances of broiler. The relative average live weight (g) of broiler chickens at the end of 4^{th} week in the dietary group T_0, T_1, T_2, T_3 and T_4 were 1942.67±0.32, 1947.33±0.40, 1987.33±0.07, 1979.00±0.72 and 2085.00±1.59 respectively (Table 4). There was a significant ($P<0.05$) difference between the T_4 and control as well as the others. Moreover, there was no significant difference between the antibiotics group and the control, cinnamon and garlic-treated group. The maximum live weight was found in T_4 (2085.00±1.59) and the lowest result was in T_0 (1942.67±0.32) group. Park (2008) also showed a remarkably higher body weight for broilers fed diets containing 3.0% cinnamon powder compared to those fed the control feeds, which is in alike with the findings of Chen et al. (2008a) who described that broiler supplied cinnamon extract added diets had significantly higher average daily gain and lower feed to gain ratio in the whole 6-week period compared with the control. Al-Kassie (2009) found positive effects of ground thyme and cinnamon on the live weight gain and enhancement of the health of broiler chickens, with the other performance traits, feed conversion ratio, and feed intake. Toghyani et al. (2011) showed that dietary inclusion of cinnamon @ 2 g/kg diet improved body weight significantly and revealed that it could be an alternative to antibiotics in broilers. Therefore, the addition of cinnamon and garlic in broiler diet increases the average live weight and a significantly increased weight is observed when cinnamon and garlic are added combined.

Average body weight gain

The data presented in Table 4 also showed that the effect of feeding cinnamon and garlic on total body weight gain (gram per broiler chicken) broiler. From the table, it is clear that there is significant difference in total body weight gain among the treatments. The relative total body weight gain (g) of broiler chickens in the dietary group T_0, T_1, T_2, T_3 and T_4 were 1902.67±0.33, 1907.33±0.41, 1947.33±0.07, 1939.00±0.73 and 2045.00±1.60 respectively. The highest result was found in T_4 (2045.00±1.60) and the lowest result was in T_0 (1902.67±0.33) group. Moreover, the individual cinnamon (T_2) and garlic (T_3) group also shows significantly ($P<0.05$) better results than the control and antibiotic groups. Similarly, Gbenga et al. (2009) showed that weight gain, average feed intake and FCR of the birds receiving dietary garlic were not significantly increased, but broiler chicks fed garlic-supplemented diets had insignificantly higher weight gain than those fed the control diet which was higher at a high level of garlic supplementation. This study results highlighted that the combination of cinnamon and garlic significantly increases the average body weight gain in broiler.

Feed intake

Data presented in Table 4 showed that the result of different treatments on final feed consumption (gram per broiler chicken) were not significant ($P>0.05$). The mean of total feed consumption of broiler chicks at the end of 4^{th} week in the dietary group T_0, T_1, T_2, T_3 and T_4 were 2549.58±1.00, 2550.00±0.30, 2589.95±0.50, 2578.87±0.80 and 2678.95±0.50 respectively. The highest average feed consumption was found in T_4 (2678.95±0.50) and lowest result was in

T_0 (2549.58±1.00) group. Garlic extract (2.25 mL/kg of feed) stimulated chicken's appetite, outcome in higher feed intake and thereby higher body weight gains (Brzoska et al., 2015). Hernandez et al. (2004) reported no difference in the feed intake or FCR in broilers fed 200 mg/kg of diet with essential oils extracted from oregano, cinnamon and pepper or 5000 mg/kg of diet with labiates extract from sage, thyme and rosemary. Windisch et al. (2008) reported that improved feed intake and digestive secretions are also observed in animals given phytobiotic-supplemented feed. Though the feed consumption increases with the addition of cinnamon and garlic in feed but there was no significant difference among the treatments.

Feed conversion ratio (FCR)

Data presented in the Table 4 showed that FCR of broiler chicken was not significant (P>0.05) among the treatment groups. However, FCR in the dietary group T_0, T_1, T_2, T_3 and T_4 were 1.34, 1.34, 1.33, 1.33, and 1.31 respectively. It was found that antibiotics, herbs and phytogenic products could control and restrict the growth and colonization of numerous pathogenic and nonpathogenic species of bacteria in chicks' gut. This may lead to greater efficiency in the utilization of food, resulting in strengthen growth and improved feed efficiency (Bedford, 2000). In the current study, the positive impact of the additives on the digestive system and nutrient absorption is more distinct at younger ages, since the improved FCR seen in all supplemented groups at 28 day period was not reflected at slaughter age possibly due to the facts that older birds' nutrient requirements decrease with age. Cinnamon components (cinnamaldehyde and eugenol) have antibacterial and antiviral activity against a wide range of pathogens (Chang et al., 2001). The selective inhibition by cinnamaldehyde of pathogenic intestinal bacteria could have had a pharmacological role in balancing the intestinal microbiota in chicks resulting in better-quality productive traits. Jamroz and Kamel (2002) suggested that broilers fed with a combination of essential oils like capsaicin, carvacrol and cinnamaldehyde showed higher weight gain and better FCR. In this study, better FCR is obtained may be due to the better intensive management, lower mortality rate and the positive effect of cinnamon and garlic in the ration. Therefore, the cinnamon, garlic and the combined group of cinnamon & garlic showed better FCR than the control and antibiotic group.

Dressing percentage (DP)

In this study, the DP of dietary treatment groups T_0, T_1, T_2, T_3 and T_4 were 72.57±0.20, 74.87±0.10, 75.95±0.06, 75.99±0.32 and 76.21±0.24 respectively. However, the T_4 (0.2% cinnamon + 0.2% garlic) group showed better DP than the T_0 (control) and other groups. Al-Kassie (2009) found that different levels of oil extract obtained from thyme and cinnamon had significant effects on DP, abdominal fat, and internal organs percentage (liver, heart and gizzard). Therefore, the addition of cinnamon and garlic in broiler diet can improve the DP of commercial broiler.

Survivability

The survivability rate is presented in Table 4. Survivability rate was higher for the control, cinnamon, garlic and the combined cinnamon and garlic treated group (100±0.00) than the antibiotic group (95.56±0.50) but there was no significant (P>0.05) difference amongst them.

The overall survivability (0-4 weeks) during the experimental period was higher in the treatment groups. This result is similar to the result Valavi et al. (2015) who reported that supplementation of diets with garlic and cinnamon powder may improve antioxidant system and some blood parameters in broilers showed to heat stress. Therefore, the possible cause of survivability in this study might be due to the development of immunity amongst the treatment groups than the control.

Carcass characteristics

Carcass weight

Data presented in Table 5 displayed that the carcass weight in the different treatment groups is better than the control and antibiotic groups. The results discovered that the treatments had significant effects ($P<0.05$) on dressed breast, back, and wing in the T_4 treatment than the other treatments. However, there is no significant difference in thigh and drumstick within the treatment groups. However, in the treatment T_4 group (0.2% cinnamon + 0.2% garlic) the carcass weight is better than in other treatment groups. Javandel et al. (2008) and Onibi et al. (2009) found that garlic enhancement had no important impact on the main components of the carcass and the structures of the liver. Raeesi et al. (2010) suggested that between various treatments, enrichment of 1.0% and 3.0% garlic in the broiler diet had no major influence on the relative weights of carcasses, fat pads, or digestive organs. Garcia et al. (2007) perceived that a blend of oregano, cinnamon and pepper oil (200 ppm) had no influence on carcass weight of broilers. However, breast weight (% of carcass) appeared to increase after the incorporation of a plant extract based on a blend of clove and cinnamon oil (100 ppm). Koochaksaraie et al. (2011) discovered that supplementation of cinnamon powder at the dose of 250 to 2000 mg/kg broiler diets did not have any effect on the carcass parameters. Therefore, the present study suggested that the addition of cinnamon and garlic in broiler diet separately and combined improve the carcass characteristics in broiler.

Relative weight of internal organs

Data presented in Table 6 showed the relative weight of internal organs (liver, heart, neck, gizzard, intestine, spleen and bursa) of broilers fed diet containing cinnamon, garlic, 0.2% cinnamon + 0.2% garlic and control and antibiotic added group. The results showed significant differences ($P<0.05$) among the different groups. The T_4 (0.2% cinnamon + 0.2% garlic), T_3 (0.2% garlic) and T_2 (0.2% cinnamon) treated group showed better result than the control group. It was also observed that there was no significant difference among the groups for the immune organ intestine, spleen and bursa but in all cases T_4 (0.2% cinnamon + 0.2% garlic) group showed better results than the others. Lee et al. (2003) discovered no significant differences in the internal organs of the broiler chickens when integrated with cinnamaldehyde (100 ppm). The Labiatae extract and the blend of carvacrol, cinnamaldehyde and capsaicin improved the digestibility of the feeds but no consequences were noted on organ weight (Hernandez et al., 2004). Feeding increasing levels of garlic up to 1.0% to male broilers for 7 weeks did not alter carcass yield and parts, organ weights, and intestinal mucous (Carrijo et al., 2005). Najafi and Taherpour (2014) stated no significant effect ($P>0.05$) on the relative weights of spleen, bursa of fabricius and thymus with dietary treatment of cinnamon. Therefore, in cinnamon and garlic

treated groups, the weight of internal organ is higher than in control group. This might be due to the positive effect of cinnamon and garlic on carcass trait of chicken.

Immune parameters

The immune parameter mainly WBC, Lymphocyte and Granulocyte was counted and the data has presented in Table 7. The WBC, Lymphocyte and Granulocyte were statistically significant (P>0.05) among different treatments. The highest granulocyte was in control (11.20±0.10) which indicates low immunity in control group. The lowest WBC (5.00±1.00), Lymphocyte (2.05±0.13) and Granulocyte (3.50±0.10) found in T_4 (0.2% Cinnamon + 0.2% Garlic). Although reports on the effect of garlic and cinnamon on immune responses in broilers are scarce, our results have similarity to Jafari et al. (2008) who observed that the inclusion of 1.0 and 3.0% of garlic powder did not enhance the serological response of broilers to newcastle vaccine. Cinnamon has great potential as a natural alternative medicine for the cure and inhibition of many serious diseases (Alzheimer's Parkinson's and Diabetes) and for its anti-inflammatory and anti-proliferative activities. Hossain et al. (2014) recommended that 1.0% cinnamon powder had a significant impact to increase the antibody SP ratio (ratio of sample and positive control) for Newcastle disease and lower the blood glucose level. According to the present findings, it is recommended that the addition of cinnamon and garlic in broiler feed significantly increases the immunity in broiler.

CONCLUSION

The research was conducted to investigate the potentiality of cinnamon and garlic on growth performance, carcass traits and immune parameters of commercial broilers. It could be concluded that the addition of cinnamon and garlic performed positively more or similar to antibiotic separately and the significant performance was observed when the cinnamon and garlic are added combined on growth performance, carcass characteristics and immune parameters of broiler chickens than the control and antibiotic groups. Therefore, the study recommended that the addition of cinnamon or garlic individually and combinedly of 0.2% cinnamon and 0.2% garlic to feed as an alternative to antibiotics in broiler production can be applied to prevent the human health hazard.

ACKNOWLEDGEMENT

The authors appreciate to the Ministry of Science and Technology, Govt. of the People's Republic of Bangladesh for financial assistance of this research project.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

REFERENCES

Agarwal KC (1996). Therapeutic actions of garlic constituents. Medical Research Review, 16 (1): 111–124.

Al-Kassie GA (2009). Influence of two plant extracts derived from thyme and cinnamon on broiler performance. Pakistan Veterinary Journal, 29(4): 169-173.

Amagase H, BL Petesch, H Matsuura, S Kasuga and Y Itakura (2001). Intake of garlic and its bioactive components. Journal of Nutrition, 131 (S3): 955S–962S.

Ankri S and D Mirelman (1999). Antimicrobial properties of allicin from garlic. Microbes Infection, 1: 125–129.

Bedford M (2000). Removal of antibiotic growth promoters from poultry diets: implications and strategies to minimize subsequent problems. Worlds Poultry Science Journal, 56: 347–365.

Brzoska F, B Sliwinski, O Michalik-Rutkowska and J Sliwa (2015). The effect of garlic (*Allium sativum* L.) on growth performance, mortality rate, meat and blood parameters in broilers. Annals of Animal Science, 15: 961–975.

Carrijo AS, LA Madeira, JR Sartori, AC Pezzato, JC Goncalves, VC Cruz, KV Kuibida and DF Pinheiro (2005). Powdered garlic in the alternative feeding of broiler chickens. Pesquisa Agropecuária Brasileira, 40: 673–679.

Carvalho IT and L Santos (2016). Antibiotics in the aquatic environments: a review of the European scenario. Environment International, 94: 736e57.

Chang ST, PF Chen and SC Chang (2001). Antibacterial activity of leaf essential oils and their constituents from *Cinnamomum osmophloeum*. Journal of Ethnopharmacology, 77: 123–127.

Chang ST, FH Yeh, YC Luo, YC Lin, SS Cheng and RY Hsu (2013). Methods for thermal stability enhancement of leaf essential oils and their main constituents from indigenous Cinnamon (*Cinnamomum osmophloeum*). Journal of Agricultural and Food Chemistry, 61(26): 6293-6698.

Chen A, J Xu, C Yang and Q Hong. (2008a). Effects of cinnamon extracts on growth performance and excreta urease activity and nitrogen loss in broilers: VIII Livestock Environment Conference, Iguassu Falls, Brazil, 331–338 pp.

Chen YJ, IH Kim, JH Cho, JS Yoo, Q Wang, Y Wang and Y Huang (2008b). Evaluation of dietary L-carnitine or garlic powder on growth performance, dry matter and nitrogen digestibilities, blood profiles and meat quality in finishing pigs. Animal Feed Science of Technology, 141: 141–152.

Demir E, S Sarica, MA Ozcan and M Suicmez (2003). The use of natural feed additives as alternatives for an antibiotic growth promoter in broiler diets. British Poultry Science, 44 (Suppl. 1): S44–S45.

Diarra MS, H Rempel, J Champagne, L Masson, J Pritchard and E Topp. (2010). Distribution of antimicrobial resistance and virulence genes in Enterococcus spp. and

characterization of isolates from broiler chickens. Applied Environment Microbiology, 76: 8033e43.

Forgetta V, Rempel H, Malouin F, Vaillancourt Jr R, Topp E and K Dewar et al. (2012). Pathogenic and multidrug-resistant *Escherichia fergusonii* from broiler chicken. Poultry Science, 91: 512e25.

Furtula V, Farrell EG, Diarrassouba F, Rempel H, Pritchard J and MS Diarra et al. (2010). Veterinary pharmaceuticals and antibiotic resistance of *Escherichia coli* isolates in poultry litter from commercial farms and controlled feeding trials. Poultry Science, 89: 180e8.

Garcia V, Catala-Gregori, Hernandez F, Megias MD and J Madrid (2007). Effect of formic acid and plant extracts on growth, nutrient digestibility, intestine mucosa morphology and meat yield of broilers. Journal of Applied Poultry Research, 16: 555-562.

Gardzielewska JK, Pudyszak T, Majewska M, Jakubowska J and Pomianowski (2003). Effect of plant-supplemented feeding on fresh and frozen storage quality of broiler chicken meat. Electronic Journal of Polish Agricultural University, 6:12-12.

Gbenga EO, EA Oluwatoyin, NF Adebowale and VA Ayodeji (2009). Response of broiler chickens in terms of performance and meat quality to garlic (*Allium sativum*) supplementation. African Journal of Agricultural Research, 4 (5): 511-517

Gonzalez Ronquillo M and JC Angeles Hernandez (2017). Antibiotic and synthetic growth promoters in animal diets: review of impact and analytical methods. Food Control, 72: 255e67.

Gurdip S, M Sumitra, MP DeLampasona and ANC Cesar (2007). A comparison of chemical, antioxidant and antimicrobial studies of cinnamon leaf and bark volatile oils, oleoresins and their constituents. Food Chemistry Toxicology, 45: 1650–1661.

Hernandez F, J Madrid, V Garcia, J Orengo and MD Megias (2004). Influence of two plants extracts on broilers performance, digestibility and digestive organ size. Poultry Science, 83: 169-174.

Hossain M et al. 2014. Evaluation of locally available herbs and spices on physical, biochemical and economical parameters on broiler production. International Journal of Plant, Animal and Environmental Sciences, 4: 317-323.

Jafari RA, M Ghorbanpoor and S Hoshmand Diarjan (2008). Effect of dietary garlic on serum antibody titer against Newcastle disease vaccine in broiler chicks. Journal of Biological Science, 8 (7): 1258–1260.

Jakhetia V, R Patel, P Khatri, N Pahuja, S Garg, A Pandey and S Sharma (2010). Cinnamon: A pharmacological review. Journal of Advanced Scientific Research, 1: 19-23.

Jamroz D and C Kamel (2002). Plant extracts enhance broiler performance. Journal of Animal Science, 80-141.

Javandel F, B Navidshad, J Seifdavati, GH Pourrahimi and S Baniyaghoub (2008). The favorite dosage of garlic meal as a feed additive in broiler chickens ratios. Pakistan Journal of Biological Sciences, 11(13): 1746-9.

Kim YJ, SK Jin and HS Yang (2009). Effect of dietary garlic bulb and husk on the physicochemical properties of chicken meat. Poultry Science, 88: 398–405.

Kim DK, HS Lillehoj, SH Lee, SI Jang and D Bravo (2010). High throughout gene expression analysis of intestinal intraepithelial lymphocytes after oral feeding of carvacrol, cinnamaldehyde or capsicum oleoresin. Poultry Science, 89: 68-81.

Koochaksaraie RR, M Irani and S Gharavysi (2011). The effects of cinnamon powder feeding on some blood metabolites in broiler chicks. Brazilian Journal of Poultry Science, 13: 197-101.

Lee KW, H Everts, HJ Kappert, M Frehner, R Losa and AC Beynen (2003). Effects of dietary essential oil components on growth performance, digestive enzymes and lipid metabolism in female broiler chickens. Brazilian Poultry Science, 44: 450–457.

Lee KW, H Everts, HJ Kappert, H Wouterse, M Frehner and AC Beynen (2004). Cinnamaldehyde, but not thymol, counteracts the carboxymethyl cellulose-induced growth depression in female broiler chickens. International Journal of Poultry Science, 3 (9): 609–612.

Montes-Belmont R and M Carvajal (1998). Control of *Aspergillus flavus* in maize with plant essential oils and their components. Journal of Food Protocol, 61: 616–619.

Najafi S and K Taherpour (2014). Effects of dietary Ginger (*Zingiber officinale*), Cinnamon (*Cinnamonum*), Synbiotic and antibiotic supplementation on performance of broilers. Journal of Animal Sciences Advances, 4(1): 658-667.

Onibi GE, OE Adebisi and AN Fajemisin (2009). Response of broiler chickens in terms of performance and meat quality to garlic (*Allium sativum*) supplementation. African Journal of Agricultural Research, 4(5): 511-517.

Park and Byung-Sung (2008). Effect of dietary cinnamon powder on savor and quality of chicken meat in broiler chickens. Journal of Korean Society of Food Science & Nutrition, 37 (5): 618–624.

Prasad G, VA Laxdal, M Yu and BL Raney (1995). Antioxidant activity of allicin, an active principle in garlic. Molecular Cell Biochemistry, 148: 183–189.

Raeesi M, SA Hoseini-Aliabad, A Roofchaee, ZA Shahneh and S Pirali (2010). Effect of periodically use of garlic (*Allium sativum*) powder on performance and carcass characteristics in broiler chickens. World Academy of Science, Engineering and Technology, 44: 1223-1229.

Sang-Oh P, R Chae Min, P Byung-Sung and H Jong (2013). The meat quality and growth performance in broiler chickens fed diet with cinnamon powder. Journal of Environmental Biology, 34: 127-133.

Sterling SJ and RD Eagling (2001). Agronomic and allicin yield of Australian grown garlic (*Allium sativum*). Acta Horticulture, 555: 63–73.

Tabak M, R Armon and I Neeman (1999). Cinnamon extracts' inhibitory effect on Helicobacter pylori. Journal of Ethnopharmacology, 67: 269–277.

Tapiero H, DM Townsend and KD Tew (2004). Organosulfur compounds from alliaceae in the prevention of human pathologies. Biomedical Pharmacother, 58: 183–193.

Toghyani M, A Gheisari, G Ghalamkari and S Eghbalsaied (2011). Evaluation of cinnamon and garlic as antibiotic growth promoter substitutions on performance, immune responses, serum biochemical and haematological parameters in broiler chicks. Livestock Science, 138(1): 167-173.

Valavi M, H Sarir, H Farhang Far, A Zarban, SJ Hosseini-Vashan and HN Younosi (2015). Evaluation of the effect of garlic and cinnamon powder on performance, antioxidant system, blood parameters of broilers under heat stress conditions. Research on Animal Production, 7(14).

Windisch WM, K Schedle, C Plitzner and A Kroismayr (2008). Use of phytogenic products as feed additives for swine and poultry. Journal of Animal Science, 86: 140-148.