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RESPONSE OF BROILER CHICKENS TO DIETARY SUPPLEMENTATION OF GINGER (ZINGIBER OFFICINALE) CONTINUOUSLY OR INTERMITTENTLY IN COMPARISON WITH PREBIOTICS

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ABSTRACT: Arbor Acres broiler chickens (n=140), 7-day-old, were used in a straight-run complete randomized experimental design. The broilers were distributed among four treatment groups with five replicates per treatment and seven chickens per replicate. During the experimental period (7-42 day-old), the chickens were fed iso-caloric and iso-nitrogenous diets with ginger (Zingiber officinale) level of 0.5% given either continuously or intermittently (two treatments), mannanoligosaccharide (MOS) of 0.05%, and the unsupplemented control. The objective of this study was to study the response of broiler chickens to continuous or intermittent supplementation with ginger as phytogenic additive compared with MOS on performance and cost of supplementation. The intermittent treatment was given as two days per week. Feeding 0.5% ginger resulted in higher body weight gain (BWG), European production efficiency factor (EPEF) and economic efficiency (EE) than MOS, however, feed conversion ratio (FCR) was similar among different experimental groups. Ginger level of 0.5% continuously decreased serum aspartate aminotransferase (AST), increased serum globulin, and 0.5% ginger intermittently increased antibody titer to Newcastle disease virus (NDV). Ginger given continuously or intermittently significantly decreased meat lipids and plasma glucose with intermittent supplementation showed stronger effect on meat lipids than continuous supplementation. Hence, it could be concluded that 0.5% ginger given continuously can replace MOS as a prebiotic without negative effects on productive performance, carcass traits, meat quality, blood constituents and immune response as compared with the control and this warrant further investigation.

Key words: Ginger,broilers, productive performance, physiological traits, immune response

INTRODUCTION

Feed additives are essential supplements for improving the utilization of feeds, immunity and health of animals (Attia and Al-Harthi, 2015; Attia et al., 2017). In the past, antibiotics were widely utilized as a growth promoter in animal nutrition (Grashorn, 2010; Nasir and Grashorn, 2010). However, due to public concern, antibiotic utilization in animal nutrition was restricted causing an increase in diseases, morbidity and mortality of animals (Khan et al., 2012; Attia et al., 2014a, b and Attia et al., 2017). Phytochemicals are considered as secondary plant metabolites and suggested as growth promoters for animals (Cross et al., 2007; Grashorn, 2010; Zhang et al., 2009; Attia and Al-Harthi, 2015).

Ginger is the rhizome of the plant Zingiber officinale, consumed as a delicacy, medicine, condiment or spice (Khan et al., 2012; Ahmed et al., 2014). Ginger contains gingerol and shogaol and can improve digestion via increasing protease enzyme (El-Deek et al., 2002). It has antibacterial and anti-inflammatory actions, and ginger rhizome is known to decrease cholesterol level in the blood (Tanabe et al., 1993; Zhang et al., 2009; Saeid et al., 2010; Rehman et al., 2011). Ginger was found to possess antioxidants, and anti-diabetic properties (Al-Amin et al., 2006; Zhang et al., 2009; Morakinyo et al., 2011), and immunity enhancers (Al-Shuwaili et al., 2015). The recommended dose of ginger in the diets for chickens was found to be about 1% level (Eltazi, 2014; Bamidele and Adejumo, 2012) while increasing the dose over 1% can increase the cost of feeding (Al-Homidan, 2005; Karangiya et al., 2016). Emerging evidences indicate that the cost of supplementation can be considerably decreased with intermittent supplementation with adequate animal performance (Nasir and Grashorn, 2010; Attia et al., 2014a). Ginger was found to be an alternative growth promoter for antibiotics (Demir et al., (2003). In addition, ginger was reported to increase growth, survival rate, and improve feed utilization (Issa and Omar, 2012; Oleforuh-Okoleh et al., 2014). Ginger was observed to enhance the antimicrobial and antioxidants status of animals and improve their performance (Zhang et al., 2009; Khan et al., 2012; Habibi et al., 2014), and improve the quality of animal products (Naveena and Mendiratta, 2001; Saranya et al., 2016).

Mannanoligosaccharide (MOS) is prebiotic that contains a yeast cell wall component such as chitin, mannan and glucans (Hooge, 2004). Mannanoligosaccharide has been known as immunostimulants and extensively examined as feed additives with some success and recommended as standard prebiotics in poultry nutrition (Hooge and Connolly 2011; Attia et al., 2016). Prebiotics such as MOS are able to improve growth performance and the immune status of different animal species (Rodriguez et al., 2003; Attia et al., 2014a and b) as reviewed by Hooge (2004), Rosen (2007), and Hooge and Connolly (2011). Therefore, the objectives of this study were to evaluate the response of growth performance, meat quality and blood constituents, antioxidant status and immune response of broiler chickens to dietary ginger supplementation either continuously or intermittently in comparison with prebiotics.

MATERIALS AND METHODS

Chickens, experimental design, and diets

Arbor Acres broiler chickens (n=140), 7-day-old, were used in a straight-run experimental design. The broilers were distributed in a completely randomized design among four treatment groups with five replicates per treatment and seven chickens per replicate. Each replicate was kept in battery brooders in wire cages (55×50×35 cm length-width-height). During the experiment period (7-42 day-old), the chickens were fed iso-caloric and

iso-nitrogenous diets with ginger (Zingiber officinale) level of 0.5% given either continuously or intermittently (two treatments), and mannanoligosaccharide of 0.05%, and the unsupplemented control. The intermittent treatment was given as 2 days per week.

Husbandry of chickens

The broilers were reared using common husbandry practices for broilers, according to the breeder management guide, and fed a commercial mash diet during 7-21, 22-35 and 36-42 days of age (Table 1). During the preliminary period (1-6 days of age), chickens were fed the same starter feed offered during 7-21 days of age (Table 1). The average brooding temperatures were 34, 32, 30 and 28º C during the 1st, 2nd, 3rd and 4thweeks of age. The average outdoor temperature was 29.5ºC with 32% RH. Mash feed and water were provided ad libitum. The vaccination regimen was Hitchiner + IB on day 8, avian influenza (AI) (H5N2) on day 9, Gumboro on day 14 and day 24, and Newcastle disease virus (NDV) via Lasota on days 14, 20 and 30. The chickens were provided with a 23:1 light-dark cycle. During the experimental period, chickens were kept under similar managerial and hygienic conditions.

Measurements

At seven, 28 and 42 days of age, the broilers were weighed (g) and their feed intake was recorded for the same period. Subsequently, their feed intake was calculated and the FCR was estimated using the intakes of feed, divided by body weight gain. European production efficiency factor (EPEF) was calculated as following= (Average grams gained/day × % survival rate)/Feed conversion ratio × 10. Economic efficiency was calculated using (input- output analyses/ input) × 100.

At 42 days of age, six chickens as three of each sex from each treatment, representing the average weight of the treatment, were slaughtered according to the Islamic method to determine carcass criteria and inner organs, including lymphoid organs, which were expressed as a percentage of the pre-slaughter weight.

A meat sample (n=6 per treatment as three of each sex), consisting of 50% of the deboned thigh meat and 50% of the deboned breast meat of the slaughtered chickens, was collected on day 42 for determination of chemical and physical analyses of meat. About 200g of each sample was wrapped and frozen at -18°C until used for chemical analyses. A part of each of the fresh meat samples was used to determine the physical characteristics of the meat. The method of Volvoinskaia and Kelman (1962) was used to determine the water-holding capacity (WHC) and tenderness of the meat. Color intensity as the optical densities of the meat and drip were measured using the colorimetric method, and the pHs of the meat and drip were as reported by Husani et al., (1950) and Aitken et al., (1962), respectively. The chemical analyses of meat samples such as moisture, protein, ether extract and ash, were determined according to Association Official Analytical Chemists (AOAC, 2004), methods numbered 925.04, 990.3, 2003.06 and 942.05, respectively.

Five blood samples per treatment were collected on day 42, in unheparinized and heparinized tubes, to determine some of the haematological and biochemical constituents. Blood samples were centrifuged at 3000 rpm for 20 minutes, and the plasma and serum were stored at -20°C for further analyses. The blood's haematological characteristics, such as haemoglobin (Hgb) and packed cell volume (PCV), were determined based on Eilers' (1967) method; red blood cells (RBCs) were determined as suggested by Hepler (1966); and the blood mean cell volume, mean cell haemoglobin and mean cell haemoglobin concentration (MCHC) were calculated. The white blood cells (WBCs) and WBCs' fractions were measured as described by Lucas and Jamroz (1961); the phagocyte index (PI) and activity (PA) were measured as suggested by Leijh et al.

(1986); and plasma glucose (Trinder, 1969), serum total protein (Weichselbaum, 1946), serum albumin (Doumas et al., 1977) and serum globulin (Coles, 1974) were determined. In addition, the albumin-to-globulin ratio was calculated.

The serum aspartate aminotransferase and alanine aminotransferase (ALT) were gauged according to Reitman and Frankel's (1957) method. Renal function, creatinine, and urea were assessed in the serum based on the suggestions of Bartles et al. (1972) and Sampson et al. (1980), respectively, and the urea-to-creatinine ratio was calculated. Alkaline phosphatase (ALP) enzymes were measured according to the method of Kind and King (1954). The total plasma triglycerides, cholesterol, high-density lipoprotein, and low-density lipoprotein were assessed according to the methods of Randrup et al. (1960), Watson (1960), Friedwald et al. (1972). and Wieland and Seidel (1983), respectively. Whereas, the very-low-density lipoprotein was determined as plasma triglycerides/5 (https://labtestsonline.org/understanding/analytes/vldl/tab/sample/).

The methods of Koracevic et al. (2001) and Richard et al. (1992) were used to determine the total antioxidant capacity (TAC) and malondialdehyde (MDA), respectively. The serum antibody titres for NDV and AI were measured as suggested by Takatsy (1956), and Kai et al. (1988) respectively, and the infectious bursal disease (IBD) was determined according to Cosgrove (1962) method.

Statistical evaluation

An analysis of variance was done using a one-way analysis of variance for the most of traits, whereas two-ways factorial analyses were used for carcass and meat quality traits as described by SAS® (2009). The replicate was the experimental unit. All percentages were transformed to log10 to normalize the data distribution before analysis. The mean difference at $P \leq 0.05$ was tested using the Student-Newman-Keuls test. The survival rate was analyzed using the chi-square test.

RESULTS AND DISCUSSION

The results for growth performance are displayed in Table 2. The results indicate that different feed additives did not significantly affect BWG during 7-28 days of age. However, during 29-42 and 7-42 days of age, feed additives significantly affected BWG. The results reveal that the control group and ginger supplemented continuously of 0.5% had superior BWG than the other groups. The results demonstrate that continuous supplementation increased growth compared to intermittent one, suggesting that 0.5% ginger given continuously gave better results than (MOS) as growth promoter for broilers during 7-42 d of age. These results are similar to those reported by Habibi et al. (2014) who found that there were no significant differences in growth of 42 and 49 d old broilers between ginger powder (7.5 and 15 g/kg diet or 75 and 150 mg ginger essential oils) and the control groups. However, George et al. (2013) observed that increased ginger levels (0, 2, 4 and 6 g/kg diet) significantly increased growth in a stepwise manner during 6-56 d of age. In addition, Karangiya et al. (2016) found that supplementation with 1% ginger significantly increased the growth of broilers. However, ginger concentrations (0, 1, 1.5 and 2%) had no significant effects on growth and mortality rate of broilers (Zomrawi et al., 2012; 2013; Zhang et al., 2009; Ahmed et al. 2014). This contradiction among different experiments in growth rate may be due to the dose of ginger, bird's age and experimental condition (Khan et al., 2012).

Feed intake, during 7-28, 29-42 and 7-42 days of age, of the control group, and ginger supplemented continuously was significantly similar and was higher than the other groups. In addition, groups on continuous supplementation consumed more feed than intermittent during 29-42 d

and 7-42 of age. These results indicate that 0.5% ginger supplemented continuously had no adverse effects on feed intake of broiler chickens during 7-42 d of age. These results are similar to those reported by Zhang et al. (2009), Ahmed et al. (2014) and Habibi et al. (2014) who found that there were no significant differences in feed intake of broilers because of ginger supplementation as a powder or essential oils. However, George et al. (2013) observed that increased ginger levels (0, 2, 4 and 6 g/kg diet) significantly increased feed intake in a stepwise manner during 6-56 d of age. In addition, supplementation with 1% ginger (Karangiya et al., 2016) and 0.5% (Zomrawi et al., 2012) significantly increased feed intake compared to the other groups. However, in a further experiment (Zomrawi et al., 2013) found that ginger root powder at 1.5 and 2% significantly decreased feed intake compared to the control group.

Different feed additives had no significant effect on FCR during different periods and survival rate; however, groups supplemented with ginger continuously had slightly better (1.9-3.7%) FCR than the other groups. In addition, the control group and those supplemented continuously with ginger exhibited significantly higher EPEF (~18%), and economic efficiency (~25.5%) than the other groups. These results are similar to those reported by Habibi et al. (2014) who found that there was no significant difference in FCR of broilers at 42 and 49 d of age between (7.5 and 15 g/kg diet ginger powder groups or 75 and 150 mg ginger essential oils groups) and the control groups. In addition, ginger levels of 0, 0.2, 0.4 and 0.6% (George et al., 2013), 0.5% (Zomrawi et al., 2012; 2013), and 1% (Karangiya et al., 2016) did not significantly affect FCR and mortality of broiler chickens, but significantly improved production index of broiler chickens (Karangiya et al., 2016). Moreover, ginger up to 0.75 % had no significant effect on FCR and cost of feeding per kg gain of broilers during 1-42 days of age (Zhang et al., 2009; Mohammed and Yusuf, 2011; Ahmed et al., 2014), which is similar to the present findings.

Table 3 shows the effects of dietary feed additives on the dressing percentage, abdominal fat and inner body organs of 42 d old broilers. There were no significant differences between different feed additives and the control groups in the dressing percentage. However, groups supplemented with 0.5% ginger continuously exhibited significantly higher dressing percentage than those in MOS. There were no significant effects of feed additives on abdominal fat, proventriculus, and pancreas percentages. Similar to the present findings, ginger root powder up to 2% (Zomrawi et al., 2012; 2013) and 1.5% or ginger essential oils up to 0.15% (Habibi et al., 2014) had no significant effect on dressed carcass percentage. In addition, Zhang et al. (2009) found that ginger significantly increased carcass yield compared to the control group, but the abdominal fat was slightly lower.

Liver percentage of the group in 0.5% ginger diet given intermittently was significantly higher than that of other groups. In addition, the group given 0.5% ginger intermittently showed higher liver and gizzard percentage than its counterpart group given ginger continuously and only higher gizzard percentage than the control group. Heart and gizzard percentages of the MOS group were higher than that of the control group. It was noticed that intestinal percentage of ginger and MOS groups was significantly higher than that of the control group. Emerging evidence (Habibi et al., 2014) indicated that ginger powder (0.75 and 1.5%) or ginger essential oils (0.075 and 0.15 mg/kg diet) had no significant effect on liver, heart, pancreas, gizzard and small intestinal. Moreover, gingerol increases the motility of the gastrointestinal tract and have analgesic, sedative and antibacterial properties (Malu et al., 2009).

There were no differences in dressing, abdominal fat and inner body organs percentages due to sex of chickens as well as the interaction between gender, and feed additives treatments.

Table 4 displays the influences of different feed additives on the physical and chemical characteristics of meat of 42-day-old broilers. There was no significant effect on most of the physical and chemical parameters of meat, except for meat color, and lipids. The meat pH measured 24 hrs after slaughter was increased due to feeding 0.5% ginger intermittently and MOS compared to the other groups, showing an improvement in meat quality.

Meat color was higher of MOS supplemented group than that of the control groups. This may be due to the positive effect of MOS on the absorption of pigmentations` substances. On the other hand, meat lipid was significantly higher in the control and MOS group than that of ginger groups. The results indicate that ginger improved meat quality by decreasing meat lipids, particularly when 0.5% was added continuously. In literature, the effects of ginger on the chemical composition of meat and meat quality are rare. Ginger is a source of plant proteolytic enzyme (Syed Ziauddin et al., 1995). Naveena and Mendiratta (2001) reported that ginger extract showed proteolytic activity, resulting in an increase in collagen solubility and proteolysis in ginger extract treated spent hen muscle. Ginger stimulates the production of saliva (O'Hara et al., 1998). It promotes the release of bile (Kato et al, 1993). It is used as a stimulant and carminative and for dyspepsia and colic (O'Hara et al., 1998). These results may explain the decrease in meat lipids of broilers fed ginger supplemented-diets.

Females had a significantly greater pH, darker meat color (optical density), meat tenderness, meat dry matter and lipid than males, but a lower meat WHC, and percentage of protein, these changes may be due to the difference in sex hormones. There was no significant interaction between the gender of chickens and the feed additives on the physical traits of meat and most of the chemical composition with the exception of meat ash. Females in each ginger treatment had greater meat ash than males, but meat ash was lower of females on MOS groups and did not differ within the control group.

Table 5 exhibits the impacts of different feed additives on the blood metabolites and indices of liver and renal functions of 42-day-old broilers. The serum total protein was significantly lower in the groups supplemented with MOS compared with the other groups. Serum albumin of group supplemented continuously with 0.5% ginger was lower than that of the other groups, but serum globulin was higher than the MOS group. Albumin: globulin ratio was lower of group given 0.5% ginger continuously than the intermittent and MOS group.

Ginger groups showed lower serum glucose than the control group with the group given 0.5% ginger intermittent showed lower value than continuous and MOS groups. The increase in immunoglobulin protein of group fed 0.5% ginger continuously, suggested an immune enhancing effect of ginger. Similarly, Saeid et al. (2010); Zomrawi et al. (2012; 2013) showed that ginger root powder (2%) significantly decreased total protein, and serum glucose in broilers (Rehman et al., 2011). In addition, Zhang et al. (2009) observed that ginger powder significantly increased plasma total protein, albumin and globulin compared to the control group. However, Kausaret al. (1999), Ademola et al. (2004) and Habibi et al. (2014) showed no significant differences in blood protein, albumin, globulin and glucose among the four treatments of ginger powder and ginger essential oils and the control group.

There was no significant effect of feed additives on the serum total lipids, cholesterol and LDL. The groups fed the control diet and diet supplemented with

0.5% ginger continuously showed significantly lower serum triglyceride and VLDL than the other groups. Continuous supplementation of 0.5% ginger significantly decreases serum triglyceride and VLDL than that of the same dose of ginger supplemented intermittently. These results indicate the beneficial effect of 0.5% ginger given continuously on serum triglycerides, and VLDL. In this regard, blood cholesterol was significantly decreased for chickens received 2% ginger root powder (Zomrawi et al., 2012), and 1.5 and 2% (Zhang et al., 2009; Saeid et al., 2010; Rehman et al., 2011; Zomrawi et al., 2013). Ginger was shown to have cholesterol lowering properties and may be useful for the treatment of heart diseases and lung diseases (Tanabe et al., 1993; Kato et al., 1993; Kuschener and Stark, 2003). However, Ahmed et al. (2014) and Habibiet al. (2014) showed no significant differences in cholesterol, LDL, HDL, VLDL and triglyceride due to ginger powder and ginger essential oils.

There was no significant effect of different feed additives on most of the liver marker (leakage) enzymes with the exception of serum AST that was significantly decreased due to feeding 0.5% ginger powder continuously compared to the other groups. These results indicate that ginger supplementations decreased serum liver leakage enzymes and may enhance liver functions via improving cell membrane permeability. These results are similar to those reported by Nasir and Grashorn (2010), Rehman et al. (2011), Attia and Al-Harthi (2015) and Attia et al. (2017). The positive effects of ginger on liver functions could be due to its antimicrobial and antioxidants substances (Grashorn, 2010; Khan et al., 2012). In this regard, Zhang et al. (2009) observed that 0.5% ginger significantly increased superoxide dismutase (SOD), glutathione peroxidase (GSH-Px) and reduced MDA of broilers, showing that ginger reduces the lipid peroxidation damage to the cells. In addition, Habibi et al. (2014) found that ginger significantly increased TAC and reduced MDA, and ginger essential oils increased SOD in RBCs and liver and reduced MDA in liver.

Different feed additives had no effects on most of the renal function indices with the exception of serum urea, which was significantly higher of MOS groups than that of the other groups. These results indicate that ginger had no adverse effects on renal functions and this may be due to antimicrobial and antioxidants substances of ginger (Nasir and Grashorn, 2010; Attia and Al-Harthi, 2015; Attia et al., 2017). In addition, Onu (2010) and Zomrawi et al. (2012; 2013), found that ginger root powder up to 2% had no effect on serum urea and creatinine of broiler chickens.

Table 6 shows the effects of different feed additives on the RBCs and WBCs parameters of 42-day-old broilers. There was no significant effect on all RBCs characteristics. In general agreement with the present results, Zomrawi et al. (2012; 2013) showed that ginger root powder (0, 1, 1.5 and 2% ginger root) had no effect on Hgb, PCV, RBCs, MCV, MCH and MCHC percentage. However, there was significant decrease in MCH for chickens fed 2% ginger root powder diet.

There were no significant effects on most of the WBCs parameters, except for WBCs, heterophile and heterophile/lymphocytes ratio. WBCs were significantly lower for groups given 0.5% ginger continuously than the other groups. This suggested an improvement in cellular immunity of chickens supplemented with 0.5% ginger continuously. There was a significant difference in heterophile between the control group and MOS supplemented-group. MOS group significantly increased heterophile: lymphocyte ratio than the control group, however, the ginger group did not significantly differ from the other groups, suggesting an improvement in humeral/antibody immunity of MOS groups.

Table 7 demonstrates the influences of different feed additives on antioxidant indices, phagocytoses and lymphoid organs and antibody titer of 42-day-old broilers. Total antioxidant capacity, phagocyte activity and index, percentage spleen and bursa were not significantly affected by different treatments. On the other hand, the control and MOS groups exhibited significantly lower MDA than the other groups. In addition, ginger and MOS groups exhibited significantly lower percentage thymus than the control group. It was found that 0.5% ginger supplementation intermittently increased antibody titer to NDV compared to the other groups, but 0.5% continuous ginger supplementation decreased antibody titer to IBD compared to the other groups. In addition, MOS supplementation increased antibody titer to AI. These results indicate that the response of antibody titer to different diseases depends on type of feed additives. In literature, MOS was shown to have immune modulation that it enhances disease resistance and macrophage response while at the same time suppress the acute phase (fever) response (Spring et al., 2000; Ferket et al., 2002). In addition, the effect of ginger on antibody response to NDV is similar to those reported by Khan et al. (2012). Similar to the present findings, Habibi et al., 2014) observed that ginger powder (0.75 and 1.5%) or ginger essential oils (0.075 and 0.15 mg/kg diet) had no significant effect on spleen and bursa of Fabricius. Ginger of 1% induced an improvement in immunity of chickens as thymus is the site for T-lymphocytes mature (Sutherland et al., 2005).

It could be concluded that 0.5% ginger given continuously can replace MOS as a prebiotic without negative effects on productive performance, carcass traits, meat quality, blood constituents and immune response as compared with the control and this warrant further investigation.

Table (1): Ingredients and chemical composition of the experimental diets

Ingredients	**Starter, 1-21 d of age**	**Grower, 22-35 d of age**	**Finisher, 36-42 d of age**
Yellow corn	490	550	655
Soybean meal 48% CP	420	358	267
Di-calcium phosphate	20	15	16
Lime stone,	10	12.5	10
NaCl	3	3	3
Vitamin+ mineral premix[1]	3	3	3
Dl-Methionine	2.5	2.5	2.5
L- Lysine	1.5	2.0	3.5
A mixture of soybean oil and sunflower	50	54	40
Total	1000	1000	1000
Calculated[2] and determined[3] composition			
Metabolizable energy, Kcal[2]	3035	3135	3167
Crude protein, g/kg[3]	229	208	179
Calcium, g/kg[2]	9.5	9.1	8.2
Available phosphorus, g/kg[2]	5.2	4.2	4.2
Methionine, g/kg[2]	6.0	5.6	5.3
Total sulphur amino acid, g/kg[2]	9.6	9.1	8.3
Lysine, g/kg[2]	13.7	12.6	11.5
Ether extra, g/kg[3]	47	48	42
Crude fiber, g/kg[3]	33	38	42
Ash, g/kg[3]	55	52	55
Dry matter, g/kg[3]	901	912	895

[1]Vit+Min mixture provides per kg of the diet: vitamin A (retinyl acetate) 24 mg, vitamin E (dl-α-tocopheryl acetate) 20 mg, menadione 2.3 mg, Vitamin D3 (cholecalciferol) 0.05 mg, riboflavin 5.5 mg, calcium pantothenate 12 mg, nicotinic acid 50 mg, choline chloride 600 mg, vitamin B12 10 μg, vitamin B6 3 mg, thiamine 3 mg, folic acid 1 mg, d-biotin 0.50 mg. Trace mineral (mg per kg of diet): Mn 80 Zn 60, Fe 35, Cu 8, Se 0.60.

Table (2): Effects of different feed additives treatments on the body weight gain, feed intake, feed conversion ratio, survival rate, European production index and economic efficiency during 7-42 days of age

Treatments	Control	Ginger 0.5%		MOS, 0.05%	SEM	P value
		Continuous	Intermittent			
Body weight, g gain/period						
7-28d of age	851	843	779	770	26.5	0.096
29-42d of age	1035[a]	1021[a]	850[b]	872[b]	27.5	0.0002
7-42 d of age	1886[a]	1864[a]	1629[b]	1642[b]	41.7	0.0004
Feed intake, feed/ chick period						
7-28d of age	1257	1240	1119	1147	37.6	0.049
29-42d of age	1864[a]	1797[a]	1597[b]	1643[b]	58.7	0.017
7-42 d of age	3120[a]	3036[b]	2715[c]	2775[c]	68.4	0.002
Feed conversion ratio, g feed/g gain						
7-28d	1.48	1.44	1.44	1.51	0.051	0.781
29-42d	1.80	1.76	1.88	1.87	0.039	0.131
7-42 d	1.66	1.63	1.67	1.69	0.016	0.187
Survival rate, %	100	96.4	100	92.9	4.54	0.562
EPEF	325[a]	315[a]	279[b]	258[b]	3.57	0.0006
EE, %	26.4[a]	26.6[a]	21.9[b]	21.2[b]	1.07	0.003

[a,c] Means within a row with different letter superscripts are significantly different based on statistical analysis ($p \leq 0.05$). MOS=Mannanoligosaccharide; EPEF= European production efficiency factor; EE= Economic efficiency, which was calculated as (output-input/input)*100.

Table (3): Effects of different feed additives treatments on carcass characteristics of 42 d old broiler chickens

Treatments		Dressing, %	Abdominal fat, %	Proventriculus, %	Liver, %	Heart, %	Gizzard, %	Pancreas, %	Intestine, %
Control		73.0^{ab}	1.26	0.478	1.75^{b}	0.432^{b}	1.06^{b}	0.213	4.10^{a}
Ginger 0.5% Con.		74.1^{a}	1.33	0.476	1.86^{b}	0.485^{ab}	1.08^{b}	0.284	3.04^{b}
Ginger 0.5% Int.		73.1^{ab}	1.15	0.632	2.19^{a}	0.532^{ab}	1.74^{a}	0.124	3.35^{b}
MOS, 0.05%		70.3^{b}	1.52	0.593	1.73^{b}	0.669^{a}	1.93^{a}	0.338	4.08^{b}
P value		0.016	0.282	0.335	0.016	0.056	0.002	0.112	0.017
Effect of sex									
Male		73.6	1.28	0.594	1.87	0.559	1.34	0.192	3.54
Female		72.4	1.35	0.496	1.89	0.501	1.56	0.287	3.23
P value		0.133	0.619	0.194	0.912	0.335	0.176	0.136	0.197
Interaction									
Control	M	72.1	1.02	0.552	1.77	0.443	1.02	0.233	4.60
	F	73.9	1.50	0.404	1.72	0.422	1.11	0.193	4.58
Ginger 0.5% Cont.	M	74.4	1.42	0.444	1.94	0.525	1.01	0.191	3.16
	F	73.3	1.23	0.508	1.78	0.447	1.14	0.378	2.93
Ginger 0.5% Int.	M	72.6	1.09	0.824	2.24	0.596	1.56	0.115	3.18
	F	73.2	1.20	0.440	2.12	0.468	1.93	0.133	3.52
MOS, 0.05%	M	70.0	1.59	0.554	1.59	0.671	1.78	0.229	3.24
	F	70.5	1.45	0.631	1.87	0.668	1.07	0.447	2.93
SEM		1.45	0.187	0.102	0.139	0.082	0.221	0.086	0.247
P value		0.132	0.301	0.122	0.402	0.864	0.910	0.387	0.244

[a,b] Means within a column with different letter superscripts are significantly different based on statistical analysis ($p \leq 0.05$); Con= continuous; Int= intermittent; MOS= Mannanoligosaccharide**.**

Table (4): Effects of different feed additives treatments of meat quality of 42- d old broiler chickens

Treatments		Physical characteristics				Chemical composition			
		pH	Color (OD)	Tenderness, cm^2/g	WHC, cm^2/g	DM, %	Protein, %	Fat, %	Ash, %
Control		6.00	0.182^{b}	9.89	16.7	25.8	19.3	5.52^{a}	0.958
Ginger 0.5%		6.02	0.185^{ab}	9.10	17.0	25.7	19.2	5.44^{b}	0.968
Ginger 0.5%		6.15	0.192^{ab}	10.20	16.8	25.7	19.3	5.43^{b}	0.965
MOS, 0.05%		6.10	0.200^{a}	10.17	16.9	25.8	19.3	5.52^{a}	0.968
P value		0.059	0.036	0.463	0.497	0.151	0.739	0.029	0.347
Sex									
Male		6.02^{b}	0.182^{b}	9.85^{b}	17.4^{a}	25.5^{b}	19.7^{a}	4.77^{b}	0.963
Female		6.11^{a}	0.198^{a}	10.22^{a}	16.3^{b}	26.0^{a}	18.8^{b}	6.18^{a}	0.967
P value		0.034	0.002	0.055	0.001	0.0001	0.0001	0.0001	0.543
Interaction									
Control	M	5.98	0.173	9.62	17.1	25.5	19.7	4.83	0.957
	F	6.02	0.190	10.15	16.2	26.0	18.8	6.20	0.960
Ginger	M	5.99	0.180	9.59	17.5	25.4	19.8	4.69	0.960
0.5% Con.	F	6.06	0.190	10.20	16.5	25.9	18.8	6.19	0.977
Ginger	M	6.10	0.183	10.02	17.4	25.5	19.8	4.74	0.950
0.5% Int.	F	6.21	0.200	10.38	16.2	26.0	18.8	6.11	0.980
MOS,	M	6.02	0.190	10.18	17.4	25.5	19.8	4.81	0.987
0.05%	F	6.17	0.210	10.16	16.3	26.0	18.8	6.23	0.950
SEM		0.057	0.005	0.255	0.224	0.043	0.039	0.018	0.004
P value		0.799	0.865	0.625	0.935	0.546	0.949	0.249	0.0004

[a-c] Means within a row with different letter superscripts are significantly different based on statistical analysis ($p \leq 0.05$); Con= continuous; Int= intermittent; MOS= Mannanoligosaccharide**.**

Table (5): Effects of different feed additives treatments on the blood constituents, lipid metabolism and liver and renal function indices of 42-d old broiler chickens

Treatments	Control	Ginger 0.5%		MOS, 0.05%	SEM	P value
		Continuous	Intermittent			
Serum protein metabolites and plasma glucose						
Total protein, g/dl	6.25[a]	6.30[a]	6.33[a]	5.88[b]	0.078	0.003
Albumin, g/dl	3.25[a]	2.98[b]	3.35[a]	3.23[a]	0.065	0.006
Globulin, g/dl	3.00[ab]	3.32[a]	2.98[ab]	2.65[b]	0.127	0.014
Albumin/globulin ratio	1.08[ab]	0.90[b]	1.12[a]	1.22[a]	0.068	0.022
Plasma glucose, mg/dl	215[a]	206[b]	195[c]	211[ab]	1.89	0.0001
Plasma lipid metabolites						
Total lipid, mg/dl	458	463	435	440	6.91	0.035
Triglycerides, mg/dl	174[b]	176[b]	185[a]	184[a]	1.09	0.0001
Cholesterol, mg/dl	208	202	202	209	2.41	0.092
HDL, mg/100ml	43.3[a]	38.3[b]	39.5[b]	42.3[a]	0.83	0.002
LDL, mg/100ml	93.5	94.0	97.0	94.5	1.08	0.146
VLDL, mg/100ml	34.9[b]	34.2[b]	36.9[a]	36.9[a]	0.217	0.0001
Serum liver leakage enzymes						
ALT, U/L	61.8	61.0	62.5	62.5	0.558	0.214
AST, U/L	65.5[a]	53.5[b]	55.8[a]	57.5[a]	0.589	0.002
AST/ALT	1.06	1.14	1.12	1.09	0.019	0.205
ALP, U/L	12.0	11.5	11.5	11.0	0.353	0.299
Serum renal function indices						
Urea, mg/dl	22.3[b]	24.0[b]	22.3[b]	26.3[a]	0.728	0.004
Creatinine, mg/dl	12.0	12.5	12.3	12.5	0.509	0.881
Urea/Creatinine ratio	1.85	1.93	1.83	2.12	0.082	0.093

[a,b] Means within a row with different letter superscripts are significantly different based on statistical analysis ($p \leq 0.05$); MOS= Mannanoligosaccharide; HDL= High density lipoprotein; LDL= Low density lipoprotein, VLDL=Very low density lipoprotein; ALT=Alanine aminotransferase, AST=Aspirate aminotransferase; AST/ALT= Alanine aminotransferase/aspirate aminotransferase ratio; ALP=Alkaline phosphatase.

Table (6): Effects of different feed additives treatments on red blood cells parameters, white blood cells count and differential leukocytes counts of 42- d old broiler chickens

Treatments	Control	Ginger 0.5%		MOS, 0.05%	SEM	P value
		Continuous	Intermittent			
Hematological criteria						
RBC's, 10^6/mm^3	1.48	1.92	1.70	1.78	0.083	0.319
Hemoglobin, %	11.0	11.4	11.2	11.2	0.399	0.917
PCV, %	33.0	34.4	33.4	34.0	0.102	0.798
MCV, micron^3/RBC	181.6	179.4	198.4	193.0	8.79	0.390
MCH, µg	60.5	59.4	66.1	63.4	0.018	0.355
MCHC, %	33.4	33.2	33.4	33.9	0.665	0.961
white blood cells count and differential leukocytes counts						
WBC's, 10^3/mm^3	23.0^a	21.0^b	24.0^a	22.8^a	0.542	0.007
Lymphocytes, %	45.0	43.8	43.0	42.2	0.737	0.087
Monocytes, %	16.0	16.0	16.4	14.8	0.417	0.077
Basophils, %	0.60	1.00	0.60	0.40	0.211	0.277
Eosinophils, %	11.4	11.8	10.8	11.2	0.411	0.669
Heterophiles, %	27.0^b	28.4^{ab}	29.2^{ab}	31.4^a	0.830	0.013
H/L ratio	0.601^b	0.650^{ab}	0.681^{ab}	0.746^a	0.028	0.015

^{a,b} Means within a row with different letter superscripts are significantly different based on statistical analysis ($p \leq 0.05$). MOS= Mannanoligosaccharide; RBCs= red blood cell counts, PCV= packed cell volume, MCV= mean cell volume; MCH= Mean cell hemoglobin; MCHC= Mean cell hemoglobin concentration. WBCs= white blood cell; H/L= heterophile /lymphocyte ratio

Tables (7): Effects of different feed additives treatments on Antioxidant indices, immune indices, lymphoid organs and antibody titer of 42- d old broiler chickens

Treatments	Control	Ginger 0.5%		MOS, 0.05%	SEM	P value
		Continuous	Intermittent			
antioxidant indices						
TAC, mg/dl	412	413	412	413	0.776	0.882
Malondialdehyde, µmol/l	8.3[b]	11.0[a]	12.0[a]	9.3[b]	0.541	0.0007
Immune indices						
PA, %	16.6	16.2	17.2	18.4	0.631	0.116
PI, %	1.32	1.30	1.30	1.46	0.063	0.255
Lymphoid organs, %						
Spleen	0.082	0.075	0.062	0.086	0.013	0.454
Bursa	0.059	0.068	0.062	0.086	0.015	0.517
Thymus	0.401[a]	0.200[b]	0.259[b]	0.298[b]	0.055	0.033
Antibody titer (HI, Log 2)						
Newcastle disease	3.60[b]	3.80[b]	4.60[a]	4.00[b]	0.199	0.016
Infectious bursa disease	4.00[a]	3.20[b]	3.80[a]	4.20[a]	0.173	0.005
Avian influenza	2.60[b]	3.00[b]	3.60[b]	4.80[a]	0.300	0.0005

[a,b] Means within a column with different letter superscripts are significantly different based on statistical analysis ($p \leq 0.05$); MOS= Mannanoligosaccharide; TAC= Total antioxidant capacity; PA= Phagocyte activity; PI= Phagocyte index.

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الملخص العربي

استجابة الدجاج اللاحم إلى الإضافة الغذائية من الزنجبيل بصورة مستمرة أو متقطعة بالمقارنة مع البريبايوتك

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[2]قسم زراعة المناطق الجافة -كلية الأرصاد والبيئة و زراعة المناطق الجافة

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وزع 140 كتكوت من دجاج اللحم عمر 7 أيام من سلالة الأربورايكرز على أربعة معاملات غذائية بكل معاملة خمسة مكررات وبكل مكررة سبعة طيور، وتم تغذية الطيور على علائق متساوية في الطاقة والبروتين وكانت المعاملة الأولى (الكنترول)، المعاملتين الثانية والثالثة اضافة الزنجبيل بمعدل 0.5% بصورة مستمرة ومتقطعة علي الترتيب، المعاملة الرابعة اضافة الموس بمعدل 0.05%، ومعاملة الزنجبيل بصورة متقطعة كانت تضاف لمدة يومين اسبوعياً. التغذية على 0.5% زنجبيل أعطت أعلى معدل للزيادة الوزنية اليومية، ودليل الإنتاج الأوروبي، والكفاءة الإقتصادية مقارنة بالموس، بينما تشابه معدل التحويل الغذائي بين المعاملات وبدون فروق معنوية. أدى اضافة الزنجبيل بمعدل 0.5% بصورة مستمرة إلى انخفاض الاسبارتيت أمينوترانسفيراز (AST)وزيادة جلوبيولين السيرم، وأدى الزنجبيل بمعدل 0.5% بصورة متقطعة إلى زيادة مستوى الأجسام المضادة لمرض النيوكاسل. أدى الزنجبيل بصورتيه المستمرة أو المتقطعة إلى انخفاض معنوي في دهون اللحم والجلوكوز ببلازما الدم وأظهرت الصورة المتقطعة للزنجبيل تأثير أكبر معنويا على الدهون في اللحم عن الصورة المستمرة. وبالتالي نستنتج أن إضافة الزنجبيل بمعدل 0.5% بصورة مستمرة في علائق بداري التسمين ادى الى نتائج أفضل من الموس بدون تأثيرات سلبية على الكفاءة الإنتاجية، صفات الذبيحة، جودة اللحم، مكونات الدم، والاستجابة المناعية، عند المقارنة بالكنترول وهذا يحتاج للمزيد من الأبحاث.