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ACIDIFICATION OF BROILER FEEDS IN RELATION TO BONE CHEMICAL AND BIOPHYSICAL TRAITS

M.A.M. Abdelaziz, A.I.S. El-Faham, and A.Y.M. Abdelhady

Poult. Prod. Dep., Fac. of Agric., Ain Shams Uni., 11241, Egypt.

Corresponding author: Mrwan Abdelaziz; E-mail: mrwanabdelaziz@agr.asu.edu.eg

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ABSTRACT:A number of 150 one-day old Arbor Acres broiler chicks, was used to examine effects of supplementing diets, with sodium formate, formic acid, probiotics or probiotics-enzymes mix, on growth performance, some blood parameters, tibia chemical composition, and biophysical traits. Birds were distributed into 5 groups; each group was subdivided into 3 replicates of 10 chicks. Birds of control group (T1) were fed basal diets with no supplements, while birds of other groups, were fed basal diets supplemented with 2 g sodium formate/ kg (T2); 2 ml formic acid/ kg (T3); 1 g probiotics/ kg (T4) and 1 g probiotics-enzymes mix/ kg (T5). Values of LBW and BWG were not affected by different treatments. Similarly, values of TFI and FCR appeared significantly similar. Also, Ca and P intake, was not affected by dietary treatments. Blood plasma Ca concentration was increased with (T2) group. While plasma ALP activity was increased with (T4) group. Conversely, plasma P concentration was not affected by dietary treatments. Tibia Ca percentage recorded higher value with (T5) group, while tibia DM was greater with (T1) group. Alternatively, tibia wet weight, ash, and P percentages, remained insignificantly affected by any of dietary treatments. Most of tibia physical traits (TL, TSD, MCD and TV), were significantly similar among all experimental groups, except for MTBW. Likewise, most of tibia mass indices (TRI, TSI, TI and CAI), were insignificantly affected by any of experimental treatments, excluding TD values. Greater tibia stress values were recorded with (T4) and (T5) groups. While, tibia strain, implied no significant differences among all groups. In the same way, tibia of (T4) group presented significantly higher figures of MOE, RY and MBF. It might be concluded that, supplementation basal diets with sodium formate or formic acid could maintain productive performance, while tibia traits were maintained better by feed-added probiotics.

Keywords: organic acid- probiotic-enzyme- performance- tibia.

INTRODUCTION

Intensive genetic selection made it possible for broiler chickens to achieve higher body weights in shorter rearing periods (Kwiatkowska *et al.,* 2017). However, rapid growth rate prevents skeletal system from being fully mature, as legs are not capable of supporting bird's weight, which in turn might result in some leg disorders, including deformities and osteoporosis (Fleming, 2008). Hence, many studies were carried out to increase leg bone strength of broilers taking into account, requirements of both calcium (Ca) and phosphorus (P) in broilers diets (Rath *et al.,* 2000). Many of these studies were designed to apply feed additives (organic acids, vitamin D, probiotics, prebiotics and enzymes) to achieve better mineral utilization and bone mineralization. Before using organic acids, it is worth to know that dissociation of these acids in bird's gut, is pH dependent (Kumarasamy *et al.*, 2018). Also, short chain fatty acids which are used as feed acidifiers, are considered as energy source for enterocytes, essential for development of intestinal lymphoid tissue (Friedman and Bar-Shira, 2005). Furthermore, present bactericidal ability against *Escherichia coli* and *Salmonella sp.* (Kwan and Ricke, 2005). Application of feed-added organic acids in salt form, is intended for stronger and wider intestinal bactericidal effects (Kumarasamy *et al.,* 2018). This is realized as organic acid salts reach distal sections of gastrointestinal tract (Mallo *et al.*, 2012).

Formic acid and its salts are well known to improve productivity, mineral utilization, protein digestibility, pancreatic secretion and acting against pathogens, which decreases the pressure on the animal's immune system. (Desai *et al.,* 2007). Several studies indicated that addition of formic acid or its salts to broiler diets, triggers more weight gain (Panda *et al.,* 2009) higher feed intake (Abdelhady, 2015), greater feed efficiency (Helen and Christian, 2010), better feed mineral utilization (Selle *et al.*, 2004), superior bone integrity (Abdelaziz, 2015) and lower E. coli and Salmonella count (Hebeler *et al.*, 2000). Probiotics are natural feed supplements that positively influence bird's metabolic processes by improvement of digestion and absorption of feed nutrients (Younis *et al.,* 2013). Also, they provoke absorption of essential minerals such as calcium, magnesium, sodium, and potassium (Scholz-Ahrens *et al.,* 2007), which presents better mineralization and development of bones. The main positive effect of prebiotics on Ca solubility and absorption as a consequence of reducing intestinal pH (Suzuki and Hara, 2004), activation of ion exchange mechanism (de Sousa *et al.,* 2011) and increasing calbindin [protein responsible for transporting calcium within cells] concentration (Regassa and Kim, 2014). Application of probiotics in poultry feeds, affect intestinal microflora positively, as offering important influence on metabolism of nutrients and on bird's immunity (Netherwood *et al.,* 1999). Probiotics also, generates production of beneficial bacteria and inhibits toxic bacteria (Jadhav *et al.*, 2015). Its application is important for younger chicken, and their positive influence on health of humans and monogastric animals (Zorriehzahra *et al.*, 2016). According to Ali *et al.* (2015), it was reported that, prebiotic, probiotic or symbiotic supplementation at 0.5 % seemed adequate to achieve favorable results on performance and general health of broiler chicks. In addition, Zeller *et al.* (2015) found that carbohydrase enzymes might enhance accessibility of dietary phytate for broiler chickens, which enhance mineral retention and bone integrity. Studying densitometric and geometric parameters of bone structures, is of great importance as bones perform supportive, locomotive and protective functions required by broilers (Charuta *et al.*, 2013). And, these functions are essential in poultry production, because bones not only provide structural support for birds, but also, present a mineral source for all metabolic needs (Sahraei *et al.*,2012). The current trial was designed to study effects of using feed-added organic acid salt sodium formate 2 g/ kg, formic acid 2 ml/ kg, probiotics 1 g/ kg, and enzyme-probiotic mix 1 g/ kg, on productive performance, tibia bone physical measurements, tibia integrity indices and tibia mechanical traits of broiler chickens.

MATERIALS AND METHODS

The present study was carried out at the Experimental Farm, Poultry Production Department, Faculty of Agriculture, Ain Shams University, to examine effects of using sodium di-formate, formic acid, probiotics and probiotic-enzyme mix as feed additives, on growth performance, some blood parameters, and chemical and biophysical traits of tibia bone of boilers.

Birds and experimental diets:

A total number of 150 unsexed one-day old age Arbor Acres broiler chicks were housed in wire-floored cage batteries, which were allotted into 5 dietary treatment groups during the experimental period from 1 till 35 days of age. Each group of birds was allocated into 3 replicates of 10 chicks. The birds were randomly placed in cages according to the experimental design and fed diets according to group designations. Diets of (T1) were basal (control) diets with no additives, while (T2), (T3), (T4), or (T5) diets were formulated using (T1) diets plus designated feed additive; (T2): sodium di-format 2 g/ kg (Formi-NDF ® - Addcon - Germany); (T3): formic acid 2 ml/ kg diet (Formic acid ® - Sigma-Aldrish - USA); (T4): Probiotics 1 g/ kg diet (Biophantase ® - Da One Chemical - Korea); and (T5): Probiotics-enzymes mix 1 g/ kg diet (Amphi-Bact ® - Ampharma- USA).

The lighting program and rearing temperature were controlled to conform to programs recommended for this strain (Arbor Acres broiler handbook, by Aviagen, 2018). Feeds and fresh clean water, were provided *ad-libitum*, during the experimental period till 35 days of age. Composition and calculated chemical analyses of basal diets (starter; 0-14 days, grower; 15-28 days, and finisher; 29-35 days of age), are presented in Table 1. All experimental basal diets were formulated based on NRC (1994) corn-soybean meal diets to meet requirements of Arbor Acres broilers.

Performance data:

Data of live body weight (LBW) and total feed intake (TFI), were recorded for each replicate within treatments during experimental periods. Also, body weight gain (BWG) was calculated per replicate by subtracting mean initial LBW of birds from final LBW, while feed conversion ratio (FCR) was calculated as the amount of feed intake, in grams, which is required to produce out one gram of weight gain. Intake of both calcium and phosphorus (g/ bird), is calculated using percentage of these minerals in basal diets and amount of feed intake for each rearing stage.

Blood parameters:

Individual blood samples were collected at 35 days of age, from randomly 3 birds from each treatment, into 15 ml collecting sterile tubes. Blood samples were immediately centrifuged at 3000 RPM for

15 minutes to separate serum. Then serum samples were individually separated by and, transferred into a clean Eppendorf vials and stored in a deep freezer for later analysis. Concentrations of serum calcium, phosphorus (Tietz, 1995) and alkaline phosphatase (ALP) activity (Young, 2000) were assayed calorimetrically by colorimetric method using spectrophotometer commercial diagnosing kits of LINEAR chemicals S.L., Spain.

Tibia bone sampling:

At the end of the experimental period (35 days of age), tibia bone sampling was performed using three chickens selected according to the average live body weight of each treatment. After birds had been slaughtered, tibia bones of both sides were removed, cleaned of all soft tissues and cartilages and weighed in relation to LBW of birds to determine wet tibia weight percentage, as described by Charuta *et al.* (2013). Left tibiae samples were assigned to perform bone chemical analysis. As dry matter of tibia was determined using oven-drying at 105º C until constant weight, while tibia ash was measured when samples were ashed at 600º C for 3 hours. Determining concentration of Ca and P in tibia was performed by dissolving ash samples in concentrated HCl then assayed by a colorimetric method according to method 984.27 (AOAC, 1995).

Tibia measurements:

Right tibiae bones were used to determine bone physical measurements. As, tibia length (TL) (mm) and shaft diameter (TSD) (mm) were measured with a digital caliper with 0.01 mm accuracy according to the method described by Samejima (1990). Additionally, thickness (mm) of medial and lateral walls was measured as close as possible to bone midpoint, and mean thickness of bone wall (MTBW) (mm) was calculated. Then, medullary canal diameter (MCD) (mm) was calculated by subtracting thicknesses of medial and lateral walls from diameter of diaphysis (Brzóska *et al.*, 2005). All measurements of bone wall thickness were performed after bone breakage during tibia mechanical traits determination. The wet tibia volume (TV) (cm^3) was measured by the method of water weight change as described by Zhang and Coon (1992).

Tibia mass indices:

Physical bone density (g/ cm^3) were determined by the method of Watkins and Southern (1992). Tibia robusticity index (TRI) represents an indication of tibia density which was calculated according to Vahdatpour *et al.* (2014), and the lower TRI value, the denser the bone. Moreover, tibia Seedor index (TSI) also gives an indication of tibia mineral density as an absolute figure as described by Seedor *et al.* (1991). In contrast to TRI, higher TSI value, means denser tibia bone. As proposed by Brzóska *et al.* (2005), tibiotarsal index (TI) and cortical area index (CAI), were determined as following:

TI = diaphysis diameter - medullary canal diameter / diaphysis diameter X 100

CAI = diaphysis section area - medullary canal area / diaphysis section area X 100

Tibia mechanical traits:

Measurements of the bones mechanical properties were taken by means of the three-point bending test, using a universal testing machine. All these parameters were determined on tibiae at wet-basis by applying simple three-point bending concept using an Instron universal testing machine. After bone was broken, bone wall thickness measurements were made inside and outside the mid-shaft of the bone both perpendicular and parallel to the direction of applied force to calculate area moment of inertia, stress, strain as well as modulus of elasticity as described by (Kocabagli, 2001). And resistance yield was calculated as the area under the stress-strain curve up to the fracture point (Currey, 2002). Additionally, maximum breaking force was determined following method of Crenshaw *et al.* (1981).

Statistical Analyses:

The statistical analysis was conducted using the general linear model (GLM) procedures of SAS (2004). Means were compared using Duncan's Multiple Rang test (Duncan, 1955) and level of significance was set at minimum of ($P \leq 0.05$). And, statistical model was as follows:

$Y_{ij} = \mu + Ti + e_{ij}$

Where: Y_{ij} = observation of measured parameter, μ = overall mean, T_i = effect of treatment (i: 1 to 5), e_{ij} = random experimental error

RESULTS AND DISCUSSION

Growth performance:

The mean values of live body weight (LBW), body weight gain (BWG), total feed intake (TFI) and feed conversion ratio (FCR) are shown in Tables (2). Data showed that initial or final LBW and overall BWG of broiler chicks were not affected by different dietary treatments. It is worth to note that chicks fed T2 or T3 diets, presented numerically higher LBW and BWG. Similarly, values of TFI and FCR appeared significantly similar. In this regard, birds of T1 group recorded higher overall feed intake, while FCR was better with birds fed T2 or T3 diets. Regarding intake of calcium and phosphorus (Table, 3), it was noted that intake of both minerals was not affected by dietary treatments. Results of productive performance, are in partial agreement with those of El-Faham *et al.* (2014). Similarly, Abdelaziz (2015) reported similar results except for TFI, when broilers were fed on diets containing sodium formate 3 Kg/ Ton, as total feed intake was significantly reduced. Also, results of the present trial were in harmony with those of Vale *et al.* (2004), Leeson *et al.* (2005) and Gunal *et al.* (2006) who reported that feed supplementation with organic acids or organic acid salts, had no effects on LBW or FCR. On the other hand, productive performance data were in contrast with those obtained by Ali *et al.* (2015), Awad *et al.* (2013), and Soliman *et al.* (2012), who reported that adding different types of organic acids increased LBW and BWG significantly. Better performance of broilers fed organic acids or their salts was explained by many authors; as nutrient utilization was improved, gut surface was enlarged and potential pathogens were counteracted (Lückstädt and Millor, 2011; Papatsirous and Billinis, 2012; El-Naggar and Abo El-Maaty, 2017). Regarding probiotics, there were similar observations reported by Nunes *et al.* (2012) who stated no statistically beneficial effects of dietary probiotic supplementation on BWG of broilers from 1 to 42 days of age. Whereas, Shabani *et al.* (2012), reported improved FCR of birds up to 42 days of age upon supplementing diets with different types of probiotics. Furthermore, El-Faham *et al.* (2018) reported that supplementing broiler diets with probiotic enzyme mix, had no significant effects on LBW, FCR up to 42 days of age. Alternatively, Hajati (2010), reported that BWG was decreased by enzyme supplementation from 1-44 days. Additionally, Kavitha *et al.* (2007) found that presenting higher dose of probiotic in water led to poor feed conversion efficiency and higher pathogenic bacteria counts with increased beneficial bacteria.

Blood plasma parameters:

Results concerning plasma calcium (Ca) and phosphorus (P) concentrations (mg / dL), and alkaline phosphatase (ALP) activity (U / dL), are shown in Table (4). It is clear that birds of (T2) group, presented significantly higher blood plasma (Ca) concentration, when compared to control group (T1) or (T3). While, values of (T4) or (T5) appeared significantly similar (P), while being similar to control (T1) group. Regarding (P) concentrations, there were no significant differences among different dietary treatments. And, numerically, value of (T4) group, presented the highest rate among all groups. Values of (ALP) activity in blood plasma showed that values of (T1) were significantly higher than those of (T3) or (T4), while appeared similar to those of (T2) or (T5). Abdelaziz (2015) reported that supplementing broiler diets with sodium formate had no significant effect on serum P levels, while ALP activity was insignificantly depressed with treated groups. Conversely, results of plasma Ca, are in disagreement with that proposed by Tang *et al.* (2007) who reported that Lactobacillus fermentation normally leads to increase in Ca solubility which in turn enhance Ca bioavailability. Nevertheless, treatments of diet-added probiotics, might have no significant effect on blood Ca or P levels or ALP activity (Vahdatpour *et al.*, 2014)

Tibia bone composition:

Data of tibia chemical composition are summarized in Table (5). Percentage of wet tibia weight demonstrated insignificant differences within different dietary groups. However, values of dry matter (DM) percentage revealed significant differences. As, birds fed (T1) diets, showed higher value when compared with those fed other diets. And, lowest DM value was recorded with (T2) when compared to that of (T1) or (T2) groups. While, values of (T4) and (T5) appeared significantly similar that of both (T2) and (T3) groups. It is noted that ash percentage appeared insignificantly affected by different dietary treatments. And, all treatments (T2: T5) presented numerically higher ash values of ash percentage when compared to that of (T1) group. Values of tibia Ca percentage recorded highest ($P<0.01$) rate with (T5) group, which appeared similar to that of (T4) group. While, value of (T1) group presented the lowest rate, when compared to that of other groups, except for that of (T2) group. On the other hand, values of P percentage in tibia revealed no significant differences within all groups. While, value of (T4) group, was numerically higher when compared to that of other group. In broilers, Vahdatpour *et al.* (2014) reported that using probiotics in diets have no significant effect on tibia Ca, P or ash content. And in laying hens, Świątkiewicz *et al.* (2018) stated that using feed-added organic acid salt or probiotics, had no significant effects of tibia bone crude ash. In the same way, results of the present study agree with those of Ziaie *et al.* (2011) who reported that probiotics contributes to increase Ca content in bones. These finding appears logic as probiotics increase bioavailability of Ca for birds (Chawla *et al.,* 2013). Additionally, Gutierrez-Fuentes *et al.*, (2013) reported higher tibia ash, Ca and P contents when probiotics were presented in broiler diets. Higher retention of these minerals might be justified by lowered pH in duodenum, jejunum, and ileum making better environment for absorption of minerals (Ramesh *et al.,* 2000). Recent reports, have demonstrated that including organic acids or their salts in broiler diets has beneficial effects on nutrient digestibility, causing an improvement in protein and mineral digestibility thus maintain overall bone integrity (El-Naggar and Abo El-Maaty, 2017).

Tibia physical traits:

Data of different tibia bone physical traits as affected by different dietary treatments are summarized in Table (6). The obtained data showed that, there were no significant differences in tibia length (TL) values among all treatments. In the same way, tibia shaft diameter (TSD) measurements were not affected by dietary treatments. Similarly, no significant differences were observed in medullary canal diameter (MCD), among all dietary treatments. Also, values of tibia volume (TV) revealed that all treatments were significantly similar. On the other hand, values of mean thickness of bone wall (MTBW), showed significant differences within treatments. As tibia of (T2) showed higher MTBW value when compared to that of (T5), while it appeared similar to that of (T1), (T3) or (T4) groups. Although, no significant differences were noticed within treatments, with all studied traits, except for MTBW. It is worth to note that tibia of (T3) group presented numerically higher figures of TL, TSD, MCD and TV, when compared with those of other groups. Similar report was presented by Vahdatpour *et al.* (2014) when broilers were fed on diets supplemented with prebiotics, and values of TL, TSD, or MCD appeared significantly similar within all treated groups. In laying hens, using organic acid salt or probiotics as feed additive, had no significant effects on TL, TSD, or MCD (Świątkiewicz *et al.*, 2018). Similarly supplementing broilers with sodium formate had no significant effect on TL or TSD values (Abdelaziz, 2015).

Tibia mass indices:

Table (7) presents data of mass indices of tibia bone as affected by experimental dietary treatments. The present data showed significant differences in tibia density (TD) values. As tibia bones of (T5) group recorded higher value, when compared to that of (T1) or (T2) groups, while being similar to that of (T3) and (T4). Conversely, values of tibia robusticity index (TRI), appeared significantly similar within all dietary treatments. In the same way, tibia Seedor index (TSI) rates were not affected by dietary treatments. Likewise, no significant differences were observed within values of tibiotarsal index (TI), among all experimental groups. Furthermore, values of cortical area index (CAI) revealed that tibia samples of all treatments, were significantly similar. Though, no significant differences were noticed in TI or CAI values within treatments, it is noticed that tibia of (T2) group presented numerically higher figures, when compared with those of other experimental treatments. Similar TSI values were reported by Vahdatpour *et al.* (2014) when broilers fed supplemental probiotics. Recently, it was reported that tibia density recorded higher values, as probiotics were added to diets of laying hens (Kwiatkowska *et al.,* 2017). These finding were justified as probiotics increased apparent ileal digestibility of minerals and improved bioavailability of Ca (Chawla *et al.*, 2013).

Tibia mechanical traits:

Measurement of tibia mechanical parameters are summarized in Table (8). As data implies, there are significant differences among dietary treatments in regard to stress values. As, tibia of (T5) group showed significantly higher mechanical stress value, when compared to those of (T1), (T2) or (T3) groups, while appeared significantly similar to that of (T4) group. On the contrary, values of tibia strain, seemed significantly alike within all dietary treatments. Values representing modulus of elasticity (MOE) showed significant ($P<0.01$) differences among all treatments. As, tibia of (T4) group, recorded the highest value, compared to that of (T1) group, which in turn, recorded the lowest one, when compared to those of other experimental groups. And, MOE values of (T2), (T3) and (T5) were in between. Also, it is noticed that tibia of (T4) group recorded the highest resistance yield (RY) among all experimental groups, while the lowest value was recorded with that of (T5) with significant difference. Furthermore, it seemed that tibia of (T4) recorded higher maximum breaking force (MBF) value, compared to that of (T5) group, values of MBF for (T1), (T2) or (T3) group were in between. It is clear that tibia of (T4) group presented significantly higher figures of most biomechanical traits of tibia bone, when compared with those of other experimental groups. These results were in agreement with those of Abdelaziz (2015) who indicated that tibia breaking force was not affected by addition of sodium di-formate at different levels. In addition, Świątkiewicz and Arczewska-Wlosek (2012) found that chicks fed diets contained medium or short chain fatty acids, had no significant effect on tibia stiffness, yielding load or bone breaking strength. Similarly, report of Mutus *et al.* (2006) showed that values of elasticity and yield stress, were not significantly affected by treating broiler diets with supplemental probiotics. Likewise, in laying hens, Świątkiewicz *et al.* (2018) found that using organic acid salt or probiotics had no significant effects on tibia bone breaking strength, yielding load, or bone stiffness. While, Islam *et al.* (2012) reported that adding citric acid to broiler diets, presented higher MBF for tibia bones. Similar results were obtained from earlier reports by Panda *et al.* (2006) who reported that dietary supplementation with probiotics, had significantly enhanced bone breaking strength.

CONCLUSION

Finally, through reviewing all obtained results, it would be advisory to state that, using sodium formate or formic acid as supplements to broiler diets, might maintain parameters of productive performance, while traits of tibia bone were maintained better by using supplements of feed-added probiotics.

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CONFLICT OF INTERESTS

The authors declare that there are no conflicts of interest regarding the publication of this paper organic acid- probiotic-enzyme- performance- tibia.

Table (1): Feed ingredients and chemical analyses of experimental basal diets.

Ingredients	**Experimental Basal Diets**		
	Starter (0-14 days)	**Grower (15-28 days)**	**Finisher (29-35 days)**
Yellow Corn Grains	51.55	57.23	62.59
Soy Bean Meal 44%	35.00	29.79	24.70
Corn Gluten Meal 60%	5.20	4.90	4.60
Soy Oil	3.50	4.00	4.25
DL-Methionine	0.31	0.24	0.21
Lysine - HCl	0.32	0.25	0.23
Limestone ($CaCO_3$)	1.35	1.10	1.08
Di-Ca Phosphate	1.90	1.68	1.55
Salt (NaCl)	0.40	0.40	0.40
Premix*	0.30	0.30	0.30
Anti-oxidant	0.17	0.11	0.09
Total	100	100	100
Chemical Analysis (Calculated)			
Crude Protein %	23.01	21.01	19.04
ME Kcal/ Kg diet	3046	3159	3238
Calcium %	1.07	0.90	0.85
Available Phosphorus %	0.51	0.45	0.42
Lysine %	1.45	1.25	1.10
Methionine and Cysteine %	1.08	0.95	0.87

* Each 3 Kg of premix contains: Vitamins: A: 12000000 IU; Vitamins; D_3 2000000 IU; E: 10000 mg; K_3: 2000 mg; B_1:1000 mg; B_2: 5000 mg; B_6:1500 mg; B_{12}: 10 mg; Biotin: 50 mg; Choline chloride: 250000 mg; Pantothenic acid: 10000 mg; Nicotinic acid: 30000 mg; Folic acid: 1000 mg; Minerals: Mn: 60000 mg; Zn: 50000 mg; Fe: 30000 mg; Cu: 10000 mg; I: 1000 mg; Se: 100 mg and Co: 100 mg.

Table (2): Effect of different dietary treatments on live body weight (LBW), body weight gain (BWG) and total feed intake (TFI).and feed conversion ratio (FCR).

Items	Experimental Treatments					Sig.
	T1	T2	T3	T4	T5	
LBW (1 day)	38.83±0.01	38.44±0.01	38.73±0.01	39.60±0.01	38.34±0.01	NS
LBW (35 days)	1859.58±60.45	1888.70±29.62	1883.38±62.20	1770.01±25.01	1814.82±58.20	NS
BWG (g) (0-35 days)	1820.75±60.45	1850.26±29.62	1844.62±62.20	1730.40±25.01	1776.48±58.20	NS
TFI (g) (0-35 days)	2949.14±10.62	2887.06±36.65	2908.72±97.72	2895.15±88.70	2891.19±47.90	NS
FCR (0-35 days)	1.62±0.04	1.56±0.02	1.57±0.01	1.67±0.04	1.63±0.06	NS

T1: basal diet, T2: basal diet + Sodium di-formate 2 g/ Kg, T3: basal diet + Formic acid 2 ml/ Kg, T4: basal diet + Probiotics 1 g/ Kg, T5: basal diet + Probiotic + Enzyme mix 1 g/ Kg.

Table (3): Effect of different dietary treatments on calcium and phosphorus intake.

Items	Experimental Treatments					Sig.
	T1	T2	T3	T4	T5	
Ca intake (g) (0-35 days)	26.70±0.11	26.13±0.29	26.31±0.87	26.17±0.80	26.23±0.42	NS
P intake (g) (0-35 days)	13.25±0.05	12.97±0.15	13.06±0.43	12.99±0.40	13.01±0.21	NS

T1: basal diet, T2: basal diet + Sodium di-formate 2 g/ Kg, T3: basal diet + Formic acid 2 ml/ Kg, T4: basal diet + Probiotics 1 g/ Kg, T5: basal diet + Probiotics-enzymes mix 1 g/ Kg.

Table (4): Effect of different dietary treatments on some blood plasma parameters.

Items	Experimental Treatments					Sig.
	T1	T2	T3	T4	T5	
Ca mg / dL	10.46^{b}±0.40	13.10^{a}±0.66	10.60^{b}±0.72	11.93^{ab}±0.46	11.50^{ab}±0.66	*
P mg / dL	3.98±0.16	4.83±0.40	3.96±0.04	4.92±0.52	4.02±0.03	NS
Alkaline Phosphatase activity U / dL	288.46^{a}±18.59	273.23^{a}±28.75	206.56^{bc}±15.39	185.30^{c}±6.55	259.30^{ab}±23.15	*

a, b, c, d Means within the same row with different superscripts are significantly different. Sig. = Significance, ** (P≤0.01), * (P≤0.05).
T1: basal diet, T2: basal diet + Sodium di-formate 2 g/ Kg, T3: basal diet + Formic acid 2 ml/ Kg, T4: basal diet + Probiotics 1 g/ Kg, T5: basal diet + Probiotics-Enzymes mix 1 g/ Kg.

Table (5): Effect of different dietary treatments on some tibia composition traits.

Items	Experimental Treatments					Sig.
	T1	T2	T3	T4	T5	
Wet Tibia Weight %	0.56±0.03	0.59±0.02	0.58±0.01	0.60±0.02	0.58±0.02	NS
Tibia DM %	$70.43^{a}\pm0.74$	$67.75^{b}\pm1.26$	$64.52^{c}\pm0.36$	$66.04^{bc}\pm1.01$	$66.26^{bc}\pm0.34$	*
Tibia Ash %	37.01±1.29	39.13±2.32	39.76±1.11	40.41±1.32	39.63±1.93	NS
Tibia Ca %	$11.72^{c}\pm0.14$	$11.73^{c}\pm0.12$	$12.39^{b}\pm0.22$	$12.70^{ab}\pm0.14$	$13.12^{a}\pm0.06$	**
Tibia P %	7.19±0.05	7.16±0.02	7.25±0.08	7.39±0.07	7.23±0.10	NS

a, b, c, d Means within the same row with different superscripts are significantly different. Sig. = Significance, ** (P≤0.01), * (P≤0.05).
T1: basal diet, T2: basal diet + Sodium di-formate 2 g/ Kg, T3: basal diet + Formic acid 2 ml/ Kg, T4: basal diet + Probiotics 1 g/ Kg, T5: basal diet + Probiotics-Enzymes mix 1 g/ Kg.

Table (6): Effect of different dietary treatments on some tibia physical traits.

Items	Experimental Treatments					Sig.
	T1	T2	T3	T4	T5	
Tibia Length (mm)	86.82±2.13	87.48±1.86	89.23±1.71	88.42±0.92	87.94±1.01	NS
Tibia Shaft Diameter (mm)	8.72±0.25	8.44±0.11	8.72±0.22	8.52±0.30	8.32±0.28	NS
Medullary Canal Diameter (mm)	5.21±0.35	4.74±0.10	5.35±0.25	5.13±0.21	5.19±0.36	NS
Tibia Volume (cm^3)	9.22±0.90	9.14±0.27	9.56±0.34	9.14±0.55	8.39±0.30	NS
Mean Thickness of Bone Wall (mm)	$1.75^{ab}\pm0.06$	$1.85^{a}\pm0.07$	$1.68^{ab}\pm0.09$	$1.69^{ab}\pm0.06$	$1.56^{b}\pm0.07$	*

a, b, c, d Means within the same row with different superscripts are significantly different. Sig. = Significance, ** (P≤0.01), * (P≤0.05).
T1: basal diet, T2: basal diet + Sodium di-formate 2 g/ Kg, T3: basal diet + Formic acid 2 ml/ Kg, T4: basal diet + Probiotics 1 g/ Kg, T5: basal diet + Probiotics-Enzymes mix 1 g/ Kg.

Table (7): Effect of different dietary treatments on some tibia mass indices.

Items	Experimental Treatments					Sig.
	T1	T2	T3	T4	T5	
Tibia Density (g/ cm³)	1.20^{b}±0.01	1.19^{b}±0.02	1.22^{ab}±0.01	1.23^{ab}±0.01	1.24^{a}±0.01	*
Tibia Robusticity Index	3.92±0.06	3.94±0.06	3.93±0.03	3.95±0.03	4.02±0.02	NS
Tibia Seedor Index	1.27±0.10	1.25±0.03	1.31±0.02	1.26±0.05	1.18±0.02	NS
Tibiotarsal Index	40.37±2.48	43.85±1.36	38.61±2.23	39.77±0.84	37.75±2.51	NS
Cortical Area Index	64.24±3.04	68.63±1.63	62.28±2.77	63.74±0.98	61.03±3.15	NS

a, b, c, d Means within the same row with different superscripts are significantly different. Sig. = Significance, ** (P≤0.01), * (P≤0.05).
T1: basal diet, T2: basal diet + Sodium di-formate 2 g/ Kg, T3: basal diet + Formic acid 2 ml/ Kg, T4: basal diet + Probiotics 1 g/ Kg, T5: basal diet + Probiotics-Enzymes mix 1 g/ Kg.

Table (8): Effect of different dietary treatments on some tibia mechanical traits.

Items	Experimental Treatments					Sig.
	T1	T2	T3	T4	T5	
Stress (N/ mm²)	8.13^{b}±0.22	8.72^{b}±0.18	6.00^{c}±0.20	11.34^{a}±0.23	11.48^{a}±0.16	*
Strain	0.04±0.01	0.02±0.01	0.02±0.01	0.02±0.01	0.03±0.01	NS
Modulus of Elasticity (n/ mm²)	236.71^{e}±2.95	451.57^{b}±12.81	356.13^{d}±8.29	555.15^{a}±11.66	417.77^{c}±4.75	**
Resistance Yield	551.34^{c}±12.15	590.98^{b}±11.08	539.33^{cd}±10.83	673.93^{a}±16.38	523.49^{d}±13.90	*
Maximum Breaking Force (N)	272.05^{b}±3.25	262.25^{b}±3.79	262.62^{b}±3.98	299.10^{a}±2.98	251.45^{c}±3.74	*

a, b, c, d Means within the same row with different superscripts are significantly different. Sig. = Significance, ** (P≤0.01), * (P≤0.05).
T1: basal diet, T2: basal diet + Sodium di-formate 2 g/ Kg, T3: basal diet + Formic acid 2 ml/ Kg, T4: basal diet + Probiotics 1 g/ Kg, T5: basal diet + Probiotics-Enzymes mix 1 g/ Kg.

organic acid- probiotic-enzyme- performance- tibia.

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الملخص العربي

تحميض علائق دجاج التسمين وعلاقته بالخصائص الكيميائية والحيوية الطبيعية للعظام

مروان عبدالعزيز محمود عبدالعزيز، أحمد إبراهيم سليمان الفحام، عبدالرحمن يوسف محمد عبدالهادى
قسم إنتاج الدواجن - كلية الزراعة - جامعة عين شمس - 11241 - مصر

أجريت التجربة، بإستخدام عدد 150 كتكوت عمر يوم من سلالة أربوإيكرز لدراسة تأثير إضافة فورمات صوديوم أو حامض فورميك أو بروبيوتك أو مزيج بروبيوتيك + إنزيمات للعلائق، على أداء النمو وبعض مقاييس بلازما الدم والتركيب الكيميائى والخصائص الحيوية الطبيعية لعظم الساق. وزعت الطيور على 5 معاملات غذائية، حيث قسمت المعاملات إلى 3 مكررات بكل مها عدد 10 طيور. غذيت طيور مجموعة المقارنة (T1) على علائق قاعدية (بادى، نامي وناهي) بدون إستخدام أى من الإضافات، وغذيت الطيور فى باقى المعاملات على العلائق القاعدية مضاف إليها 2 جم فورمات صوديوم / كجم (T2)، 2 مل حمض فورميك / كجم (T3)، 1 جرام بروبيوتيك / كجم (T4) و1 جرام مزيج بروبيوتيك + إنزيمات / كجم (T5). قدمت العلائق التجريبية ومياة الشرب بحرية كاملة خلال الفترة التجريبية بالكامل وحتى عمر 35 يوم. أوضحت نتائج الأداء الإنتاجي أن وزن الجسم الحي ووزن الجسم المكتسب، لم تتأثر معنوياً بالمعاملات المختلفة. بالمثل، فإن معدلات استهلاك العلف الكلى ومعامل التحويل الغذائي، لم تُظهر أى فروق معنوية بين المعاملات الغذائية المختلفة. كذلك فإن معدل الإستهلاك التراكمى لكل من عنصرى الكالسيوم والفوسفور لم تتأثر بالمعاملات التجريبية. أوضحت معدلات مقاييس بلازما الدم، أن تركيز عنصر الكالسيوم إزداد مع المعاملة الغذائية (T2). فى حين إزداد نشاط إنزيم ألكالين فوسفاتيز مع المعاملة الغذائية (T4). على النقيض، فإن معدلات عنصر الفوسفور فى البلازما لم تتأثر بأى من المعاملات الغذائية. إزدادت نسبة الكالسيوم فى عظام الساق للطيور المغذاة المعاملة الغذائية (T5)، فى حين إزدادت نسبة المادة الجافة فى عظام الساق للطيور التى غذيت المعاملة الغذائية (T1). على الجانب الأخر، فإن معدلات الوزن الرطب، نسبة الرماد ونسبة الفوسفور فى عظام الساق لم تُظهر فروق معنوية بين المعاملات الغذائية المختلفة. أوضحت معدلات معظم المقاييس الطبيعية لعظام الساق (الطول، القطر، قطر القناة النخاعية والحجم) عدم تأثرها بالمعاملات الغذائية، بإستثناء متوسط سمك جدار العظام والذى سجل أعلى معدل مع الطيور المغذاة المعاملة الغذائية (T2). كذلك فإن غالبية دلائل الكتلة لعظام الساق (دليل المتانة، دليل سيدور، دليل أبعاد العظام ودليل مساحة بنية العظام) لم تتأثر بأى من المعاملات الغذائية المختلفة، بإستثناء معدل كثافة العظام الذى سجل أعلى قيمة مع الطيور التى غذيت المعاملة الغذائية (T5). فيما يتعلق بالخصائص الحيوية الميكانيكية لعظام الساق، فإن أعلى معدلات إجهاد ميكانيكى لعظام الساق، تم تسجيلهم مع الطيور المغذاة المعاملة الغذائية (T4) أو (T5). فى حين أن معدلات الإلتواء الميكانيكى لم تُظهر إختلافات معنوية بين المجموعات التجريبية. بالطريقة نفسها، فقد أظهرت عظام الساق للطيور التى غذيت المعاملة الغذائية (T4)، أعلى معدلات فى مقاييس معامل المرونة، حاصل المقاومة ومعدل قوة الكسر ، وذلك عند مقارنتها مع باقى المجموعات التجريبية. يمكن أن نستخلص من هذه الدراسة، أن إضافة فورمات الصوديوم أو حمض الفورميك إلى العلائق القاعدية، تدعم الحفاظ على أداء إنتاجي جيد لدجاج اللحم، كما أن إستخدام البروبيوتيك، يحقق مقاييس عظام الساق بشكل أفضل، عند مقارنة ذلك مع المجموعات التجريبية الأخرى.