Egypt. Poult. Sci. Vol. (42) (III): (243-263) (2022) **(2207-1212)**

Egyptian Poultry Science Journal

http://www.epsj.journals.ekb.eg/

ISSN: 1110-5623 (Print) – 2090-0570 (Online)

EFFECT OF GRADED LEVELS OF BIOCHAR SUPPLEMENTATION AS A GROWTH PROMOTER ON PRODUCTIVE AND PHYSIOLOGICAL PERFORMANCE OF BROILER CHICKS

El-Ghalid, O. A.[1], Abdel-Hamid, A.E. [2], Harfoush, A. S. [2] and Asmaa Sh. ELnaggar[2]

[1]Poult.Pro. Dep., Fac.of Agric. (El-Shatby), Alexandria Uni., Alexandria, Egypt
[2]Dept. of Anim. and Poult. Prod., Fac. of Agric., Damanhour Uni., Egypt

Corresponding author: Asmaa Sh. Elnaggar; Email:asmaa.elnaggar@agr.dmu.edu.eg

Received: 01/07/2022 Accepted: 20 /07/2022

ABSTRACT: This study aimed to determine the effects of graded amounts of biochar supplementation on broiler chick production index, lipid profile, biomarkers of antioxidant status, carcass characteristics, and economic efficiency. A total of 216, seven-day-old, unsexed broiler chicks (*Arbor Acres*) were divided into six experimental groups (36 chicks each), each with six replicates (6 chicks each). The first group was fed the basal diet and served as control; while the 2nd, 3rd, 4th, 5th, and 6th groups were fed the basal diet supplemented with 1, 2, 4, 6, and 8 % biochar, respectively. According to the data, treatment groups that added biochar levels of 1, 2, 4, and 6 % outperformed the control group in terms of productivity, economic efficiency, and production index. While it was at the same previous levels, total lipids, triglycerides, cholesterol, low-density lipoprotein (LDL), and malondialdehyde (MDA) were lowered. When compared to the control group, there were higher levels of glucose, thyroid hormones (T3-T4), high-density lipoprotein (HDL), total antioxidant capacity (TAC), and glutathione peroxidase (GSH-Px), and superoxide dismutase (SOD) (within normal range). In conclusion, it can be concluded that adding biochar to the diet at levels of 1, 2, 4, and 6 % improved the physiological status and growth performance of broilers without having any negative impacts on the blood parameters of broiler chicks.

Key words: Biochar, Broilers, Performance, Blood biochemical, Antioxidative status.

INTRODUCTION

The sub-therapeutic dose of antibiotics has been demonstrated in the past to enhance growth performance, animal health, and disease control. As a result, from the beginning of 2006, the use of antibiotics as growth promoters in animals raised for human consumption was prohibited in the European Union. However, developed nations have prohibited the use of antibiotics as growth promoters in animal nutrition due to the harmful effects of antibiotics, including cross-resistance and carryover impact (Diarra *et al*., 2007). There are several alternatives to antibiotic growth promoters, including prebiotics, probiotics, phytobiotics, medicinal herbs, and essential oils. (Bolukbasi *et al*., 2006; Mansoub and Nezhady, 2011; Bozkurt *et al*., 2012).

Natural cures that don't leave behind residues or lead to antibiotic resistance are the subject of research. By 2021, some European nations intend to outlaw the use of synthetic pharmaceuticals as feed additives for managing pathogenic diseases in poultry. As a result, it is imperative to employ safe practices that do not harm birds or poultry meet consumers. Therefore, it is justified to look for and use locally available, natural feed additives that have no adverse effects on human health (Hajati and Hazaei, 2010; Saleha *et al*., 2009).

Biochar (BC) is an ash material that is created by pyrolyzing organic material and burning it. The organic material is heated during this process, which causes it to break down into ash in an anaerobic atmosphere. In contrast to conventional techniques of burning, this type of decomposition prevents the creation of CO_2 due to the lack of oxygen. The biochar sequesters the carbon that would otherwise be emitted as CO_2 into solid carbon (Qian *et al*., 2015). The volatile substances are released from the biomass during pyrolysis to form a gas product. Zhao *et al*. (2008) claim that the aromatic carbon structures created during pyrolysis result in the production of biochar that is stable and mostly resistant to degradation (Prasai *et al*., 2016). The three main products produced by pyrolysis are biochar, syngas, and bio-oils, depending on the pyrolysis's intended goals and conditions (Emanuel and Ernest, 2020).

Little research has been conducted using biochar as a feed additive in animal production. The inclusion of biochar in poultry nutrition has been reported to rapidly decrease the incidence of diarrhea, eliminate allergies and ameliorate the detrimental effects of mycotoxins in feed (Marie, 2013). Biochar amended feed showed its potential in controlling poultry zoonotic pathogens (Yang *et al*., 2015). In view of these, biochar is gaining attention as a locally sourced feed additive with the capacity to improve digestibility, feed efficiency, weight gain, feed conversion ratio, and dietary energy absorption in poultry birds (Gerlach and Schmidt, 2012).

Additionally, biochar alters the composition of the microbial community and affects microbial activity by acting as an electron mediator (Chen *et al*., 2014; Kappler *et al*., 2014; Sun *et al*., 2017), and can also alter the microbial composition (Teoh *et al*., 2019; Terry *et al*., 2019). It has been demonstrated that biochar improves the digestibility of feed (Kim *et al*., 2017; Saleem *et al*., 2018).

The purpose of this study was to investigate the effects of adding biochar to broiler diets on performance, blood biochemical markers, antioxidant status, carcass characteristics, economic efficiency, and production index.

Biochar, Broilers, Performance, Blood biochemical, Antioxidative status.

MATERIALS AND METHODS

The current study was conducted to investigate the effects of adding biochar to broiler diets on performance, blood biochemical markers, antioxidant status, carcass characteristics, economic efficiency, and production index.

Biochar® powder (88% biochar substances) used in this trial is highly purified and extremely concentrated. Biochar is produced by the incomplete pyrolysis (heating to ~550˚C under oxygen-limited conditions) of organic materials such as wood, straw, manure, crop residues, and leaves. Depending on feed material and pyrolysis condition, biochar contains (on a w/dw basis) 40–80% carbon, 0.1–0.8% nitrogen, 1–2% potassium, 5–6% calcium, and can have an ion exchange capacity between 25 and 150 cmol+ /kg, registered in the Ministry of Agriculture produced by the united company for Agricultural Development (http://www.uad-eg.com).

Ethical approval:

All treatments and birds care procedures were approved by the Institutional Animal Care and Use Committee at Damanhour University, Egypt. The authors declare that the procedures imposed on the birds were carried out to meet the Directive 2010/63/EU of the European Parliament and of the Council of 22 September 2010 on the protection of animals and birds used for scientific purposes.

Birds and experimental design

A total of 216 unsexed broiler chicks (*Arbor Acres*), one week old and weighed an average of 199.5 g body weight (BW) were randomly divided into six experimental treatments with (36 chicks each), each treatment was subdivided into 6 replicates (6 chicks each). The first treatment was fed the basal diet without any supplementation (control), while the 2nd, 3rd, 4th 5th, and 6th treatments were supplied with different graded levels of 1, 2, 4, 6, and 8 % of biochar, respectively. Feed and fresh water were provided *Ad libitum*. The experiment was lasted at 42 days of age. The experimental diets were formulated according to NRC (1994). During the starter (7-21 d) and grower stages (22-42 d), chicks were fed a basal diet comprising (22.9 and 21.4%) and (3042 and 3103 kcal/kg) of crude protein and metabolizable energy, respectively.

Housing and management

The chicks were kept in breeding enclosures in an open sided house. During the first week, they received 23 hours of light, and from the second week until the end of the fattening period, they received 20 hours of light. This standard light schedule was recommended for commercial broiler chick raising. All chicks were initially incubated at 33°C, which was subsequently lowered to 30-27 °C during the second week, and with the aid of fans, an average temperature of 24 to 26 °C was maintained from 3 to 6 weeks of age.

Data collection

Performance parameters including individual live body weight (LBW, g), body weight gain (BWG, g), and feed consumption (FC, g) were recorded throughout the trial period (1-6 wk. of age). For each replicate within treatment groups, the feed conversion ratio (feed/gain ratio, FCR) was calculated.

The economic efficiency of experimental diets was estimated according to Zeweil, (1996) as the ratio between income and total feed cost during the experimental growth period. The price of the diets and biochar supplements was calculated according to the local market price at the same time as the experiment by the Egyptian pound (L.E.).

European Production Efficiency Index (EPEI) was calculated by guide (1999).

$$\mathbf{EPEI} = \frac{\mathbf{BW\ (kg)}\, x\ \mathbf{SR}}{\mathbf{PP}\ x\ \mathbf{FCR}}\, x\ \mathbf{100}$$

Where:

BW = Body weight (kg), SR = Survival rate (100% - Mortality), PP = Production period (days), FCR = Feed conversion ratio (kg feed / kg gain).

Blood sampling and haemato-biochemical parameters

At the end of the experiment (week 6), blood samples (3 mL/ sample) were collected randomly from six chicks from the brachial vein into heparinized and un-heparinized under vacuum tubes in each group. The blood samples were collected twice after 12-hour fastening. The first part of each blood sample was used to assess the hematological parameters, whereas the other (second) part and coagulated blood samples were centrifuged at 2000 rpm for 20 min to obtain plasma and serum that stored at −20 °C until analysis.

Red blood cell count (RBCs $10^6/mm^3$) was counted according to Feldman *et al*. (2000). Hemoglobin (Hb) concentration (g/dl) and the percentage of packed cell volume (PCV %) were measured according to Provan *et al*. (2009). Plasma total proteins, albumin, were measured according to guidelines and recommendation of Armstrong and Carr (1965); Doumas *et al*. (1971). Plasma globulin was calculated by subtraction of albumin from total proteins since the fibrinogen usually comprises a negligible fraction (Sturkie, 1986). Albumin to globulin ratio was also calculated. In addition, biochemical determinations included different types of globulins (α-globulin, β-globulin, and γ-globulin) according to Bossuyt (2003). Plasma glucose concentration was measured by the method of Trinder (1969). Serum total lipids and triglyceride concentrations were determined using special kits according to the recommendation of Frings *et al*. (1972). Serum cholesterol was determined according to the recommendation of Bogin and Keller (1987). Serum samples were analyzed for low-density lipoprotein (LDL) and high-density lipoprotein (HDL) using the colorimetric method according to the recommendation of Warnick *et al*. (1982). The transaminase enzymes activities of serum aspartate aminotransferase (AST) and serum alanine aminotransferase (ALT), as U/L, were determined by the calorimetric method (Reitman and Frankel, 1957). Serum creatinine level was estimated according to Husdan and Rapoport (1968), while, serum uric acid was determined calorimetrically according to Majkic-Singh *et al*. (1981). Serum concentration of total tri-iodothyronine (T3) and thyroxin (T4) was assayed according to Fossati and Principe's (1982). The activity of malondialdehyde (MDA), total antioxidant capacity (TAC), glutathione peroxidase (GSH-Px), and superoxide dismutase (SOD) in the blood was measured using the method reported by Placer *et al*. (1966); Koracevic *et al*. (2001); Levander *et al*. (1983), and Nishikimi *et al*. (1972).

Slaughter procedure

Six chicks from each treatment were taken randomly at the end of the experiment and slaughtered after a 12-hour fastening period to determine carcass characteristics.

Abdominal fat was removed from the gizzard and abdominal region, and each carcass was individually weighed and estimated relatively to the pre-slaughtered weight and were removed, weighed, and the weight of each organ was estimated relative to the pre-slaughtered weight.

Statistical analysis

Data were subjected to the one-way ANOVA procedure using a statistical analysis system (SAS, 2006) with the following model:

Yij= µ+ Ti + eij

Where Yij = is the dependent variable; µ= the general mean; T= the fixed effect of treatment and eij = random error. The difference among means was determined using Duncan's new multiple range test (Duncan, 1955) at P<0.05.

RESULT AND DISCUSSION

Productive performance

Data from Table (1) shows that varying levels of biochar supplementation resulted in a significant (P≤0.05) increase in body weight (BW) at 6 weeks of age and body weight gain (BWG) from 1-6 weeks of age compared to control except the 8% treatment that showed non-significant difference. The same trend was showed for FC and FCR. A gradual increase in body weight was seen in the current study as biochar levels were raised. Overall, biochar treatments raised BW by 117.7, 115.2, 118.8, 119.03, and 107.4 % for different levels of biochar at 42 days of age, respectively. The best BW is at the levels of 1, 2, 4, and 6 %. Body weight gain was increased in a level-dependent way (P=0.001), and a similar trend was seen with BW, which reached 119.9, 117.1, 121.0, 121.3, and 108.25 % for different levels of biochar, at 42 days of age, respectively. It is clear from the data analysis of variance that different graded levels of biochar; overall chick feed consumption was non-significant. Feed conversion ratio improved significantly (P=0.001) shown in Table (1), the treatments enhanced FCR by 83.5, 88.7, 87.1, 81.5, and 98.4 %, respectively, compared to the control group.

Among different treatments, the highest improvement in LBW, BWG, and FCR were 19.0, 21.3, and -18.5 % with 6 % biochar. At 42 days of age, the lowest improvements in LBW, BWG, and FCR were 7.4, 8.3, and -1.5 %, respectively, with 8 % biochar. The improvement may be due to having significant activity in inhibiting the growth of bacteria (anti-microbial activity) that promotes the performance of the intestinal flora thereby improving digestion and enhancing the utilization of energy, leading to improved growth. These results are coincident with the results of Bakr, (2008) who showed that a feeding experiment using broiler chicks that were fed biochar made from hardwood at the inclusion rate of 0, 2, 4, and 8 % of total DM. The study that lasted for 6 weeks observed that the 2 % biochar had a significantly higher return in terms of feed intake of chicks, body weight gain, and overall feed conversion rates. Similar results on broiler chicks were observed when up to 1.0 % of DM of biochar produced from maize cob was used (Kana *et al.*, 2011). Also, two different studies were done using hardwood biochar in a six to seven weeks study that reported that the chicks that received diets having biochar tended to have improved feed conversion rates and weight gain (Majewska and

Zaborowski, 2003; Majewska *et al*., 2011). Prasai *et al*. (2016) noted that a probable mechanism of action by which biochar improves FCR is by changing the microbiota constitution in the digestive tract of birds. Amprako *et al*. (2018) stated that dietary wood charcoal could replace up to 6% of commercial broiler finisher feed without a negative effect on production performance. Also, Monica (2019) illustrated that the addition of a low concentration of biochar in broiler chicks' feed in the first three weeks of the experiment improved the growth rate compared to the control. As a feed supplement, the use of biochar is capable of improving performance traits such as weight gain, nutrient digestibility, and feed efficiency in broiler chickens and ducks (Ruttanavut *et al*. 2010 ; Gerlach and Schmidt, 2012). While the results contrast the findings of Odunsi *et al*. (2007), Kana *et al*. (2010), Jiya *et al*. (2013) reported that from 2% and higher levels of inclusion, dietary biochar is capable of depressing growth rates and final body weights of broiler chickens. Also, Kana *et al*. (2011) and Majewska *et al*. (2011) showed no improvement in feed efficiency in broiler chickens when charcoal was included in the diet.

Hematological parameters

The hematological parameters of the biochar-treated broiler were shown in Table (2). All hematological indices were within the normal range of reference values. Red blood cell (RBCs) counts increased (P=0.002) gradually as biochar levels decreased within treated groups. The increases in RBCs were 156.2, 149.8, 152.3,131.1, and 105.3 % compared with the control. It is noted that when compared to the control group, Hb concentration (g/dl) was significantly increased (P=0.001) with biochar treatments, reaching 123.7, 133.3, 127.8,131.7, and 110.6 % for treated groups, respectively. Also, the PCV % value was increased significantly (P=0.003) compared with control with biochar treatments, reaching 116.8, 110.5, 119.3,114.2, and 107.9 % for different levels of treated groups, respectively.

Usually, animals that have good blood composition tend to possess records of improved performance (Isaac *et al*. 2013). In contrast the findings of Majewska *et al*. (2009) who study the dietary supplementation of 0.3% charcoal did not have a significant effect on the hematological indices of turkey. Kana *et al*. (2014) reported that bio-charcoals had no significant effect on RBC, WBC, hemoglobin, and hematocrit values of broilers fed aflatoxin B1- contaminated diets. Boonanuntanasarn *et al*. (2014) attributed the immune-enhancing potentials of activated charcoal (biochar) to its role as a non-specific detoxifier, capable of improving the overall health conditions of animals. Dim *et al*. (2018) reported that broiler chicks fed 2% biochar /kg had the least RBC value, and this was statistically lower than the RBC values of chicks on other treatments. At the finisher phase, PCV and WBC values of broilers were not significantly affected by treatments.

Blood biochemical parameters

Protein profiles (total protein, globulin, and types of globulins) as shown in Table (3) were significantly increased (P=0.001) by the biochar treatments of chicks. The percentages of those increases in total protein compared with control were 132.6, 127.7, 125.3, 128.0, and 111.8 % for different treated groups, respectively. Likewise, the percentages of those increases in globulin compared with control were 144.9, 142.9, 133.2, 139.0, and 102.9 % respectively. Data from the same table showed the differences in the serum albumin and albumin/globulin ratio concentration were not statistically significant with biochar treatments compared to the control group. Data for serum α–globulin and β–globulin concentrations (µg/dl) of the different groups are presented in Table (3) it was not significantly affected by levels of biochar at the end of the treatment period, but broiler's serum γ–globulin it was significantly affected (P=0.001), the percentages of that increase in treatment groups compared to the control group were 201.3, 205.3, 178.9, 160.5, and 135.5 % at 42 days of age, respectively.

Biochar is similar to humic in composition and physiological effect many researchers have studied the effect of humic due to the lack of studies research on biochar, humic research will be used**.** Šamudovská and Demeterová (2010) reported that fed diets supplemented with natural humic compounds (HS) and sodium humate (HNa) improved total protein. It is well known that the blood protein profile depends on fodder quality, alimentary tract efficiency, liver, and kidneys state Kłyszejko-Stefanowicz (2005). However, Avci *et al*. (2007) reported that no significant differences in serum total protein were observed for chicks who received HA compared with the control group. Moreover, Can and Sakir (2009) confirmed that supplementation of a 2.5 kg HA/ ton diet caused no statistical difference in serum total protein of broilers. In this connection, Ghazalah *et al*. (2022) concluded that serum protein of broiler fed diet supplemented with different levels of HA at 39 days of age gave significantly higher total protein, globulin, and β –and γ -globulin in the serum than the control group. However, HA supplementation did not significantly effect on albumin and Alb/Glob ratio of broiler at 39 days of age.

Total cholesterol test measures all of the cholesterol in all the lipoprotein particles. Triglycerides measure all the triglycerides in all the lipoprotein particles; most are in the very low-density lipoproteins (VLDL). High-density lipoprotein cholesterol (HDL-C), measures the cholesterol in HDL particles; often called "good cholesterol" because it removes excess cholesterol and carries it to the liver for removal. Low-density lipoprotein cholesterol (LDL-C) calculates the cholesterol in LDL particles; often called "bad cholesterol" because it deposits excess cholesterol in the walls of blood vessels (A.A.C.C., 2017).

The results of Table (4) show the lipids profile values at 42 days of age, broiler chicken is affected by diets supplemented with different levels of biochar. The results observed significant differences among treatments only on total lipids (P=0.002), cholesterol (P=0.001), triglyceride (P=0.004), HDL (P=0.003), and LDL (P=0.001) values. At the end of the treatment period, there was a significant decrease in serum total lipids concentration (mg/dl) and this decrease was in different levels of biochar. Thus, the percentage of differences compared with the control group mean was 78.7, 83.5, 79.3, 75.1, and 93.6 % for treated groups, respectively. It can be observed that biochar treatments resulted in a significant decrease in broiler's serum cholesterol. Thus, the percentages of the differences compared with the control group mean were 68.5, 75.5, 75.6, 77.8, and 92.2 % for different levels of biochar groups, at 42 days of age, respectively. From Table (4) it can be seen that broiler chickens treated with biochar gave the highest mean of serum triglycerides (TG) at the end of the treatment period when compared with the control group. Thus, the percentage of the differences compared with the control group mean was 110.6, 132.3,123.2, 122.2, and 90.1% for biochar groups, respectively. Also, the results of the present study showed a significant decrease in mean serum low-density lipoprotein (LDL) of broiler chickens with biochar treatments at the end of the treatment period when compared with the control group. Thus, the percentage of the differences compared with the control mean was 60.2, 66.0, 74.2, 78.4, and 95.8 % for biochar-treated groups, respectively. Also, it can be seen that broiler chickens treated with biochar gave the highest mean of serum high-density lipoprotein (HDL) at the end of the treatment period when compared with the control group. Thus, the percentage of the differences compared with the control group mean was 125.5, 119.2, 111.0, 109.5, and 102.4 % for biochar groups, respectively.

These results are coincident with the results of Neuvonen *et al*. (1989) observed that there was a significant decrease in cholesterol levels of birds fed the highest inclusion levels of biochar (6%) compared to birds on other treatments. It was shown intake of biochar (activated charcoal) has the potential to interfere with the enterohepatic circulation of bile acids and cholesterol, thereby lowering serum cholesterol levels in hypercholesterolemic conditions. This finding is similar to the result of Boonanuntanasarn *et al*. (2014) observed that significant differences existed in cholesterol values of Nile Tilapia fed dietary activated charcoal, which appeared to decrease as the level of activated charcoal increased in the diets. Dim *et al*. (2018) showed that there were no significant differences observed for high-density lipoprotein (HDL) and triacylglycerol (TG) across the various treatment means. However, significant differences existed among treatments in cholesterol and low-density lipoprotein (LDL) values. The result of the study however disagrees with the reports of Majewska *et al*. (2009) whose study showed that no significant differences existed in triglycerides and total cholesterol levels and other biochemical indices of 20-week-old turkeys fed diets containing charcoal, silica grit, and hardwood ash.

Results presented in Table (5) showed the changes in glucose concentration during the treatment period. It can be seen that the biochar levels treated group had a significantly higher mean compared with the control group. Thus, the percentage of the differences compared with the control mean was 116.9, 110.4, 122.1, 115.8 and 104.7 % for treated groups, respectively. Also, treating the broiler chicks with the levels from biochar resulted in a significant increase in triiodothyronine (T3) when compared with the control group. Thus, the percentage of the differences compared with the control mean was 158.5, 162.6, 131.8, 157.2, and 127.4 %. From Table (6) it can be seen that thyroxin (T4) was significantly increased (P=0.001) at the level of the biochar-treated group when compared with the control group. Thus, the percentage of the differences compared with the control mean was 120.4, 124.6, 124.0, 126.6, and 109.3 % for treated groups, respectively. Results indicated that there was a non-significant effect of biochar treatment on the T3 / T4 ratio during the experimental period.

The better body weight gain seen in this study with biochar is likely due to enhanced glucose and T3 utilization on the overall influence on metabolism, the growth process, and production performance (Table 2). Thyroid hormones stimulate the utilization of lipid substrates owing to an increased mobilization of triglycerides stored in adipose tissue that can explain the lower lipids profile observed in this study with different levels of biochar (Table 4).

Blood plasma glucose was observed to increase constantly with increasing dietary levels of biochar in the present work. These results are coincident with the results of Dim *et al*. (2018), Kalus *et al*. (2020). Glucose is involved in numerous metabolic processes, and its concentration in blood is precisely regulated by complex mechanisms (Braun and Sweazea, 2008). Šamudovská and Demeterová (2010) reported that when chickens were fed diets supplemented with natural humic compounds (HS) and sodium humate (HNa), a higher value of glucose in the HNa group was observed after 35 days of the experiment in comparison with the control group.

Triiodothyronine hormone is the main hormone that regulates growth by controlling the body's energy, and protein anabolism. So, the increase in thyroid hormones due to HA supplementation may be attributed to the effective role of HA in protecting the thyroid gland from oxidative damage due to any excess hydrogen peroxide resulting during the synthesis of thyroid hormones (Arthur *et a*l., 1999).

When liver cells are damaged or destroyed, the enzymes in the cells leak out into the blood, where they can be measured by blood tests. Liver tests check the blood for two main liver enzymes: aspartate aminotransferase (AST) and many other tissues besides the liver alanine aminotransferase (ALT). At the end of the treatment period, the results of means revealed that the broiler chicks treated with the biochar levels had no significant AST and ALT means. Results presented in Table (6) showed the at the end of the treatment period, the results of means revealed that the broiler chicks treated with the biochar levels had no significant creatinine and uric acid means.

These results are in agreement with those of Rath *et al*. (2006) reported that supplementation of humic acid in broilers resulted in non-significant decreases in the creatinine concentrations. Besides, they added that there was a trend for a decrease in serum ALT concentrations with supplementation of 2.5 % humic acid in broilers. Hanafy and El-Sheikh (2008) used laying hens and indicated that humic acid supplementation had no significant effect on AST and ALT concentration. But, Abdel-Mageed (2012) showed that feeding HS-supplemented diets resulted in a significant decrease in ALT and AST concentrations as compared to the control diet.

Results presented in Table (7) showed the indicators of the antioxidative status of all treated groups. Malondialdehyde (MDA), total antioxidant capacity (TAC), the activity of glutathione peroxidase, (GSH-Px), and superoxide dismutase (SOD), are all these parameters' indicators of oxidative stress. It is clear from the data analysis of variance that activity of TAC, GSH-Px, and SOD under different dietary biochar levels have significantly increased (P=0.001) compared to control at end of the experimental period on the contrary for MDA values significantly decreased (P=0.001) compared to the control group.

From Table (7) it can be seen that broilers treated with biochar gave the lowest mean of MDA at the end of the treatment period when compared with the control group. Thus, the percentage of the differences compared with the control mean was 91.6, 89.3, 92.3, 87.2, and 97.5 % for biochar-treated groups respectively. The results showed the biochar levels had higher TAC means when compared with the control group. Thus, the percentage of the differences compared with the control mean was 118.0, 129.1, 142.7, 135.0, and 106.8 % for biochar-treated groups respectively. Biochar levels at the end of the treatment period presented highly increase in GSH-Px when compared with the control group. Thus, the percentage of differences compared with the control mean was 145.2, 117.7, 105.7, 135.5, and 140.8 % for biochar-treated groups respectively. Also, at the end of the treatment period, broilers of chicks treated with biochar levels had a better SOD value than the control group. Thus, the percentage of the differences compared with the control mean was 162.0, 140.0, 139.0, 144.0, and 126.0 % for biochar-treated groups respectively.

These obtained results may be due to the biochar-containing antioxidants which inhibit free radicals, on the other hand, leading to maintaining a normal level of enzymes. These findings corroborate those of Dim *et al*. (2018), and Kalus *et al*. (2020). It is well known that GSH plays a vital role in the detoxification of hydrogen peroxide and protects the cell from injury caused by peroxides. The basic function of GSH- Px is the elimination of excessive peroxide and hydrogen peroxide of fatty acids resulting from oxidative elimination of lipids (Almeina *et al*., 2012). Supplementation of HA in the broiler diets decreased malondialdehyde (MDA) compared to the control. This finding is in agreement with EL Naggar and El-Kellaway (2018) and Ghazalah *et al*. (2022).

Carcass characteristics

Table (8) summarizes the effects of biochar treatment on carcass characteristics in broiler chicks at the end of the study period. Overall, biochar treatments enhanced the percentage of the carcass by 109.2, 106.5, 109.3, 106.4, and 102.7 % of the control group with biochar treatments, respectively. But, weight percentages of the liver, gizzard, and pancreas were not significantly different among experimental groups. Regarding biochar, overall chick abdominal fat (%) was considerably reduced (P=0.001), reaching 71.4, 65.9, 53.5, 56.8, and 59.3 % of control group chicks.

These findings are consistent with those of Kana *et al*. (2011) indicated that birds fed 0.2, 0.4, and 0.6% of charcoal had not been significantly affected by charcoal on carcass yield and percentage of the liver, heart, and abdominal fat. The result of this study confirmed that of Abdel-Fattah *et al*. (2008) also found that dietary organic acids had no effect on carcass yield and the live weight of broiler chickens.

Economic efficiency of the experimental diets

Results of economic efficiency in Table (9) shows economic efficiency, relative economic efficiency (%), and European Production Efficiency Index (EPEI) that were used to assess the economic viability of various levels of biochar. Supplementing with biochar in the nutritional programs altered net revenue, which is represented by the equation NR = total revenue - total feed cost, indicating that net revenue increased as dietary nutrient levels increased by supplementing with biochar. The best level biochar 1, 2, 4, and 6 % produced the best economic efficiency and relative economic efficiency (%) compared to the other treatments. The addition of biochar has improved total revenue, NR, economic efficiency, relative economic efficiency (%) and EPEI.

Therefore, it is advised to include biochar with levels 1, 2, 4, 6% in the poultry diet to improve performance and health status, which will benefit the owners of commercial farms to raise the economic value.

Table (1): Effect of dietary inclusion with different graded levels of biochar on productive performance of broiler chicks.

Dietary supplementations	BW (1 wk.)	BW (6 wk.)	BWG (1-6 wk.)	FC (1-6 wk.)	FCR (1-6 wk.)
Control	201.00	1860.80[b]	1659.80[b]	1659.80[b]	1.95[a]
BC (1%)	199.28	2188.40[a]	1989.12[a]	1989.12[a]	1.63[b]
BC (2%)	199.67	2143.30[a]	1943.63[a]	1943.63[a]	1.73[b]
BC (4%)	201.00	2210.00[a]	2009.00[a]	2009.00[a]	1.70[b]
BC (6%)	200.44	2214.60[a]	2014.16[a]	2014.16[a]	1.59[b]
BC (8%)	201.17	1998.00[ab]	1796.83[ab]	1796.83[ab]	1.92[ab]
SEM	0.470	18.36	18.34	18.34	0.019
P value	0.100	0.001	0.001	0.001	0.001

[a, b] Means in the same column followed by different letters are significantly different at ($p \leq 0.05$);

SEM, Standard error of mean; BC, Biochar.

Table (2): Effect of dietary inclusion with different graded levels of biochar on erythrocytic components of broiler chicks.

Dietary supplementations	Erythrocytic components		
	RBC's ($10^6/mm^3$)	Hb (g/dl)	PCV %
Control	3.17[b]	9.72[b]	30.26[b]
BC (1%)	4.95[a]	12.03[a]	35.36[a]
BC (2%)	4.75[a]	12.96[a]	33.46[a]
BC (4%)	4.83[a]	12.43[a]	36.11[a]
BC (6%)	4.17[a]	12.81[a]	34.56[a]
BC (8%)	3.91[ab]	10.76[ab]	32.66[a]
SEM	0.103	0.223	0.747
P value	0.002	0.001	0.003

[a,b] Means in the same column followed by different letters are significantly different at ($p \leq 0.05$); SEM, Standard error of mean; RBC'S, Red blood cell counts; Hb, Hemoglobin; PCV, Packed cells volume; BC, Biochar.

Table (3): Effect of dietary inclusion with different graded levels of biochar on protein profile of broiler chicks.

Dietary supplementations	Protein profile						
	Total protein (g/dl)	Albumin (g/dl)	Globulin (g/dl)	A/G ratio	α– globulin (µg/dl)	β – globulin (µg/dl)	γ - globulin (µg/dl)
Control	5.18[b]	3.13	2.05[c]	0.82	0.74	0.55	0.76[c]
BC (1%)	6.87[a]	3.89	2.97[a]	0.72	0.88	0.57	1.53[a]
BC (2%)	6.62[a]	3.69	2.93[a]	0.88	0.80	0.57	1.56[a]
BC (4%)	6.49[a]	3.64	2.85[a]	0.68	0.79	0.73	1.36[a]
BC (6%)	6.63[a]	3.90	2.73[a]	0.89	0.91	0.76	1.22[a]
BC (8%)	5.79[ab]	3.67	2.11[b]	1.61	0.63	0.45	1.03[b]
SEM	0.212	0.107	0.141	0.002	0.021	0.021	0.131
P value	0.001	0.120	0.001	0.076	0.087	0.098	0.001

[a,b,c] Means in the same column followed by different letters are significantly different at ($p \leq 0.05$);
SEM, Standard error of mean; BC, Biochar.

Table (4): Effect of dietary inclusion with different graded levels of biochar on lipids profile of broiler chicks.

Dietary supplementations	Lipids profile (mg/dl)				
	Total lipids	Cholesterol	Triglycerides	HDL	LDL
Control	406.0[a]	180.2[a]	66.8[b]	46.3[b]	80.6[a]
BC (1%)	319.6[b]	123.3[b]	73.7[a]	58.1[a]	48.5[c]
BC (2%)	339.0[b]	136.1[b]	88.4[a]	55.2[a]	53.2[c]
BC (4%)	322.1[b]	137.3[b]	81.4[a]	51.4[a]	59.8[c]
BC (6%)	305.7[c]	140.0[b]	80.7[a]	50.7[a]	63.2[bc]
BC (8%)	380.3[ab]	166.3[ab]	60.1[b]	47.4[b]	77.2[b]
SEM	7.70	4.27	4.79	2.61	2.86
P value	0.002	0.001	0.004	0.003	0.001

[a,b,c] Means in the same column followed by different letters are significantly different at ($p \leq 0.05$);
SEM, Standard error of mean; HDL, high-density lipoprotein; LDL, Low-density lipoprotein; BC, Biochar.

Table (5): Effect of dietary inclusion with different graded levels of biochar of blood glucose and thyroid hormones of broiler chicks.

Dietary supplementations	Blood glucose and thyroid hormones		
	Glucose (mg/dl)	T3 (ng/dl)	T4 (ng/dl)
Control	170.31[b]	3.18[b]	10.16[b]
BC (1%)	202.62[a]	5.04[a]	12.23[a]
BC (2%)	190.21[a]	5.16[a]	12.66[a]
BC (4%)	212.31[a]	4.19[a]	12.60[a]
BC (6%)	200.30[a]	5.00[a]	12.86[a]
BC (8%)	179.00[ab]	4.05[ab]	11.10[ab]
SEM	7.670	0.061	0.359
P value	0.001	0.001	0.001

[a,b] Means in the same column followed by different letters are significantly different at ($p \leq 0.05$); SEM, Standard error of mean; T3, triiodothyronine; T4, thyroxine; BC, Biochar.

Table (6): Effect of dietary inclusion with different graded levels of biochar of liver and kidney functions of broiler chicks.

Dietary supplementations	**Liver and kidney functions**			
	AST (U/L)	**ALT (U/L)**	**Uric acid (mg/dl)**	**Creatinine (mg/dl)**
Control	26.12	33.42	3.08	0.92
BC (1%)	24.57	33.63	5.00	0.68
BC (2%)	27.57	36.37	4.33	0.68
BC (4%)	23.83	39.30	4.56	0.85
BC (6%)	21.23	37.80	4.27	0.89
BC (8%)	20.67	33.83	4.13	0.55
SEM	0.057	1.124	0.170	0.0396
P value	0.071	0.076	0.078	0.076

SEM, Standard error of mean; AST, aspartate aminotransferase; ALT, alanine aminotransferase; BC, Biochar.

Table (7): Effect of dietary inclusion with different graded levels of biochar on indicators of antioxidative status in blood of broiler chicks.

Dietary supplementations	**Indicators of antioxidative status in blood**			
	MDA (µmol/L)	**TAC (nmol/L)**	**GSH-Px (mmol/L)**	**SOD (U/ml)**
Control	28.08^{a}	2.06^{b}	2.99^{b}	1.00^{b}
BC (1%)	25.71^{b}	2.43^{a}	4.34^{a}	1.62^{a}
BC (2%)	25.08^{b}	2.66^{a}	3.52^{a}	1.40^{a}
BC (4%)	25.92^{b}	2.94^{a}	3.16^{a}	1.39^{a}
BC (6%)	24.48^{b}	2.78^{a}	4.05^{a}	1.44^{a}
BC (8%)	27.39^{ab}	2.20^{ab}	4.21^{a}	1.26^{ab}
SEM	4.89	0.0671	1.32	3.57
P value	0.001	0.001	0.001	0.001

^{a,b} Means in the same column followed by different letters are significantly different at ($p \leq 0.05$);

SEM, Standard error of mean; MDA, Malondialdehyde; TAC, Total antioxidant capacity; GSH-PX, glutathione peroxidase; SOD, superoxide dismutase; BC, Biochar.

Table (8): Effect of dietary inclusion with different graded levels of biochar on carcass traits of broiler chicks.

Dietary supplementations	Carcass traits (%)				
	Carcass	Gizzard	Liver	Pancreas	Abdominal Fat
Control	67.7[b]	1.066	1.500	0.533	0.911[a]
BC (1%)	73.9[a]	1.061	1.422	0.540	0.650[b]
BC (2%)	72.1[a]	1.044	1.511	0.411	0.600[b]
BC (4%)	74.0[a]	1.049	1.550	0.500	0.487[b]
BC (6%)	72.0[a]	1.078	1.460	0.523	0.517[b]
BC (8%)	69.5[ab]	0.981	1.390	0.490	0.540[b]
SEM	0.089	0.076	0.090	0.088	0.009
P value	0.001	0.002	0.126	0.090	0.001

[a,b] Means in the same column followed by different letters are significantly different at ($p \leq 0.05$);
SEM, Standard error of mean; BC, Biochar.

Table (9): Effect of dietary inclusion with different graded levels of biochar on economic efficiency of broiler chicks.

Dietary supplementations	Economic efficiency	Relative economic efficiency (%)	production index
Control	35.50[b]	100	244.58[b]
BC (1%)	42.76[a]	120.45	344.19[a]
BC (2%)	41.68[a]	117.42	337.11[a]
BC (4%)	44.98[a]	126.71	327.55[a]
BC (6%)	43.44[a]	122.37	335.91[a]
BC (8%)	38.38[ab]	108.11	275.43[ab]
SEM	2.90	--	3.34
P value	0.003	--	0.001

[a,b] Means in the same column followed by different letters are significantly different at ($p \leq 0.05$);
SEM, Standard error of mean; BC, Biochar.

REFRENCES

Ruttanavut, J., Yamauchi, K., Goto, H., and Erikawa, T. 2010. Effects of dietary bamboo charcoal powder including vinegar liquid on growth performance and histological intestinal change in Aigamo ducks. International Journal of Poultry Science, 8(3), 229-236.

Abdel-Fattah, S. A., El-Mednay, N. M., and Abdel-Azeem, F. 2008. Thyroid activity, some blood constituents, organs morphology and performance of broiler chicks fed supplemental organic acids. Int J Poult Sci, 7, 215-22.

Abdel-Mageed M.A.A.2012. Effect of dietary humic substances supplementation on performance and immunity of Japanese quail. Egypt. Poult. Sci., 32: 645-660 .

Almeina, A., Saeerens, L., De Beer, T., Remon J. P., and Vervaet, C. 2012. Upscaling and in- line process monitoring via spectroscopic techniques of ethylene vinyl acetate hot- melt extruded formulations. International journal of pharmaceutics, 439 (1-2), 223-229 .

American Association for Clinical Chemistry A. A. C. C. 2017. 69th Annual Scientific Meeting **and** Clinical Lab Expo is organized by American Association for clinical July 30 aug 03/2017.

Armstrong, W. D., and Carr, C. W. 1965. Physiological chemistry: laboratory directions. Burgess. Burges publishing, Minneololis, Minnesota, USA.

Arthur, M., Inkson, K., and Pringle, J. 1999. The new careers: Individual action and economic change. Sage.

Avci, M.; Denek, N. and Kaplan, O. 2007. Effects of Humic Acid at Different Levels on Growth Performance, Carcass Yield and Some Biochemical Parameters of Quails. Journal of Animal and Veterinary Advances, 6:1-4 .

Bakr, B. E. 2008. The effect of using citrus wood charcoal in broiler rations on the performance of broilers.

Bogin, E., and Keller, P. 1987. Application of clinical biochemistry to medically relevant animal models and standardization and quality control in animal biochemistry. J. Clin. Chem. Clin. Biochem, 25, 873-878.

Bolukbasi, S. C., Erhan, M. K., and Ozkan, A. 2006. Effect of dietary thyme oil and vitamin E on growth, lipid oxidation, meat fatty acid composition and serum lipoproteins of broilers. South African Journal of Animal Science, 36(3), 189-196.

Boonanuntanasarn, S., Khaomek, P., Pitaksong, T., and Hua, Y. 2014. The effects of the supplementation of activated charcoal on the growth, health status and fillet composition-odor of Nile tilapia (Oreochromis niloticus) before harvesting. Aquaculture International, 22(4), 1417-1436.

Bossuyt, X., Lissoir, B., Mariën, G., Maisin, D., Vunckx, J., Blanckaert, N., and Wallemacq, P. 2003. Automated Serum Protein Electrophoresis by Capillaries. Clin Chem Lab Med; 41(5):704–710.

Bozkurt, M., Küçükyilmaz, K., Catli, A. U., Çınar, M., Bintaş, E., and Çöven, F. 2012. Performance, egg quality, and immune response of laying hens fed diets supplemented with mannan-oligosaccharide or an essential oil mixture under moderate and hot environmental conditions. Poultry science, 91(6), 1379-1386.

Braun, E.J. and K.L. Sweazea 2008. Glucose regulation in birds. Comp Biochem Physiol B Biochem Mol Biol. 151:1-9.

Can, A.K. and D. T. Sakir 2009. The effect of humates on fattening performance, carcass quality and some blood parameters of broilers. Journal of animal and veterinary Advances., 8:281-284.

Chen, S., Rotaru, A. E., Shrestha, P. M., Mavlankar, N. S., Liu, F., and Fan, W. 2014. Promoting interspecies electron transfer with biochar. Sci. Rep. 4:5019. doi: 10.1038/srep05019

Diarra, M., Niquet, Y. M., Delerue, C., and Allan, G. 2007. Ionization energy of donor and acceptor impurities in semiconductor nanowires: Importance of dielectric confinement. Physical Review B, 75(4), 045301.

Dim, C. E., Akuru, E. A., Egom, M. A., Nnajiofor, N. W., Ossai, O. K., Ukaigwe, C. G., and Onyimonyi, A. E. 2018. Effect of dietary inclusion of biochar on growth performance, haematology and serum lipid profile of broiler birds. Agro-Science, 17(2), 9-17.

Doumas, B. T., Watson, W. A., and Biggs, H. G. 1971. Albumin standards and the measurement of serum albumin with bromocresol green. Clinica chimica acta, 31(1), 87-96.

Duncan, D. B. (1955). Multiple range and multiple F tests. biometrics, 11(1), 1-42.

EL naggar, A. S., and El-Kelawy, M. I. 2018. Effect of humic acid supplementation on productive performance, blood constituents, immune response and carcass characteristics of sasso chicken. Egyptian Journal of Animal Production, 55(1), 75-84

Feldman, B. F., Zinkl, J. G., and Jain, N. C. 2000. Schalm's Veterinary Hematology. Lippincott Williams & Wilkins. Philadelphia, Baltimore.

Fossati, P., and Prencipe, L. 1982. Serum triglycerides determined calorimetrically with an enzyme that produces hydrogen peroxide. Clinical chemistry, 28(10), 2077-2080.

Fringes, C. S., Fendley, T. W., Dunn, R. T., and Queen, C. A. 1972. Improved determination of total serum lipids by the sulfo-phospho-vanillin reaction. Clinical chemistry, 18(7), 673-674.

Gerlach, A., and Schmidt, H. P. 2012. The use of biochar in cattle farming. Ithaka Journal, 2012, 281-285.

Ghazalah, A. A-; El-Tahawy W. S.; Asmaa A., Ghalwash and Asmaa Sh. EL Naggar. 2022. Productive and physiological response of broiler chicks to dietary humic acid. Egypt. Poult. Sci. Vol. (42) (II): (157-170)

Hajati, H., and Rezaei, M. 2010. The application of prebiotics in poultry production. Int J Poult Sci, 9(3), 298-304.

Hanafy M., M. and A.M.H. El-Sheikh, 2008. The effect of dietary humic acid supplementation on some productive and physiological traits of laying hens. Egyptian Poultry Science Journal, 28(4): 1043-1058.

Husdan, H., and Rapoport, A. 1968. Estimation of creatinine by the Jaffe reaction: a comparison of three methods. Clinical chemistry, 14(3), 222-238.

Isaac, L. J., Abah, G., Akpan, B., and Ekaette, I. U. 2013. September). Haematological properties of different breeds and sexes of rabbits. In Proceedings of the 18th annual conference of animal science association of Nigeria (Vol. 6, pp. 24-27).

Jiya, E. Z., Ayanwale, B. A., Ijaiya, A. T., Ugochukwu, A., and Tsado, D. 2013. Effect of activated coconut shell charcoal meal on growth performance and nutrient digestibility of broiler chickens. British Journal of Applied Science & Technology, 3(2), 268-276.

Kalus, K., Konkol, D., Korczyński, M., Koziel, J. A., and Opaliński, S. 2020. Effect of biochar diet supplementation on chicken broilers performance, NH3 and odor emissions and meat consumer acceptance. Animals, 10(9), 1539.

Kana, J. R., Ngoula, F., Tchoffo, H., Tadondjou, C. D., Sadjo, Y. R., Teguia, A., and Gnonlonfin Gbemenou, J. B. 2014. Effect of biocharcoals on hematological, serum biochemical and histological parameters in broiler chickens fed aflatoxin B1-contaminated diets. J. Anim. Sci. Adv., 4 (7), 939-948.

Kana, J. R., Teguia, A., Mungfu, B. M., and Tchoumboue, J. 2010. Growth performance and carcass characteristics of broiler chickens fed diets supplemented with graded levels of charcoal from maize cob or seed of conarium. Tropical Animal Health and Production, 43 (1), 51–56.

Kana, J. R., Teguia, A., Mungfu, B. M., and Tchoumboue, J. 2011. Growth performance and carcass characteristics of broiler chickens fed diets supplemented with graded levels of charcoal from maize cob or seed of Canarium schweinfurthii Engl. Tropical animal health and production, 43(1), 51-56.

Kappler, A., Wuestner, M. L., Ruecker, A., Harter, J., Halama, M., and Behrens, S. 2014. Biochar as an electron shuttle between bacteria and Fe (III) minerals. Environmental Science & Technology Letters, 1(8), 339-344.

Kim, K. S., Kim, Y. H., Park, J. C., Yun, W., Jang, K. I., Yoo, D. I., and Cho, J. H. 2017. Effect of organic medicinal charcoal supplementation in finishing pig diets. Korean Journal of Agricultural Science, 44(1), 50-59.

Kłyszejko-Stefanowicz, L. 2005. Ćwiczenia z biochemii, wyd. I, Wyd. Naukowe PWN, Warszawa.

Koracevic, D., Koracevic, G., Djordjevic, V., Andrejevic, S., and Cosic, V. 2001. Method for the measurement of antioxidant activity in human fluids. Journal of clinical pathology, 54(5), 356-361.

Emanuel, A. and Mbega, E. 2020. Biochar as a feed additive for improving the performance of farm animals. Malaysian Journal of Sustainable Agriculture. 4. 86-93. 10.26480/mjsa.02.2020.86.93.

Levander, O. A., DeLoach, D. P., Morris, V. C., and Moser, P. B. 1983. Platelet glutathione peroxidase activity as an index of selenium status in rats. The Journal of Nutrition, 113(1), 55-63.

Amprako, L. , Mohammed, A., Andreas, B., and Regina, R. 2018. Influence of dietary wood charcoal on growth performance, nutrient efficiency and excreta quality of male broiler chickens. International Journal of Livestock Production, 9(10), 286-292.

Majewska, T., and Zaborowski, M. 2003. Charcoal in the nutrition of broiler chickens. Medycyna weterynaryjna, 59(1), 81-83.

Majewska, T., Mikulski, D., and Siwik, T. 2009. Silica grit, charcoal and hardwood ash in turkey nutrition. Journal of Elementology, 14(3), 489-500.

Majewska, T., Pudyszak, K., and Kozlowski, K. 2011. The effect of charcoal addition to diets for broilers on performance and carcass parameters. Veterinarija ir Zootechnika (Vet Med Zoot), 55, 10-12.

Majkic-Singh, N., Stojanov, M., Spasic, S., and Berkes, I. 1981. Spectrophotometric determination of serum uric acid by an enzymatic method with 2,20-azino-di (3-ethylbenzthiazoline-6-sulfonate) (ABTS). Clinica Chimica Acta 116, 117–123.

Mansoub, N., and Nezhady, M. 2011. The effect of using Thyme, Garlic and Nettle on performance, carcass quality and blood parameters. Annals of biological Research, 2(4), 315-320.

Marie, C. I. 2013. Biochar as a feed supplement. An overview. International Journal of Livestock Research, 9 (1), 58-72.

Majewska, Teresa & Pudyszak, Krzysztof and Kozlowski, Krzysztof. 2011. The effect of charcoal addition to diets for broilers on performance and carcass parameters. Veterinarija ir Zootechnika. 55. 30-32.

Monica, C. 2019. Evaluation of the effects of biochar inclusion in broiler chicken feeds and litter on growth performance and fecal bacterial count (Doctoral dissertation, BUSE) .

National Research Council (NRC) 1994. Nutrient requirements of poultry. 9.ed. Washington: National Academy, 176p

Neuvonen, P. J., Kuusisto, P., Vapaatalo, H., and Manninen, V. 1989. Activated charcoal in the treatment of hypercholesterolemia: dose-response relationships and comparison with cholestyramine. European journal of clinical pharmacology, 37(3), 225-230.

Nishikimi, M., Rao, N. A., and Yagi, K. 1972. The occurrence of superoxide anion in the reaction of reduced phenazine methosulfate and molecular oxygen. Biochemical and biophysical research communications, 46(2), 849-854.

Odunsi, A. A., Oladele, T. O., Olaiya, A. O., and Onifade, O. S. 2007. Response of broiler chickens to wood charcoal and vegetable oil-based diets. World Journal of Agricultural Sciences, 3(5), 572-575.

Placer, Z. A., Cushman, L. L., and Johnson, B. C. 1966. Estimation of product of lipid peroxidation (malonyl dialdehyde) in biochemical systems. Analytical biochemistry, 16(2), 359-364.

Prasai, T. P., Walsh, K. B., Bhattarai, S. P., Midmore, D. J., Van, T. T., Moore, R. J., and Stanley, D. 2016. Biochar, bentonite and zeolite supplemented feeding of layer chickens alter intestinal microbiota and reduces campylobacter load. PLoS One, 11(4), e0154061.

Provan, D., Singer, C. R., Baglin, T., and Dokal, I. 2009. Oxford handbook of clinical haematology. Oxford University Press.

Qian, K., Kumar, A., Zhang, H., Bellmer, D., and Huhnke, R. 2015. Recent advances in utilization of biochar. Renewable and Sustainable Energy Reviews, 42, 1055-1064.

Rath N.C.; W.E. Huff and G.R. Huff 2006. Effects of humic acid on broiler chickens. Poultry Science 85:410–414

Reitman, S., and Frankel, S. 1957. A colorimetric method for the determination of serum glutamic oxalacetic and glutamic pyruvic transaminases. American journal of clinical pathology, 28(1), 56-63.

Saleem, A. M., Ribeiro Jr, G. O., Yang, W. Z., Ran, T., Beauchemin, K. A., McGeough, E. J., and McAllister, T. A. 2018. Effect of engineered biocarbon on rumen fermentation, microbial protein synthesis, and methane production in an artificial rumen (RUSITEC) fed a high forage diet. Journal of animal science, 96(8), 3121-3130.

Saleha, A. A., Myaing, T. T., Ganapathy, K. K., Zulkifli, I., Raha, R., and Arifah, K. 2009. Possible effect of antibiotic-supplemented feed and environment on the occurrence of multiple antibiotic resistant Escherichia coli in chickens. International Journal of Poultry Science, 8(1), 28-31.

Šamudovská A. and M. Demeterová 2010. Effect of Diet Supplemented with Natural Humic Compounds and Sodium Humate on Performance and Selected Metabolic Variables in Broiler Chickens. ACTA VET. BRNO, 79: 385–393.

SAS, 2006. SAS/STAT User's guide statistics. SAS institute INC., Cary. NC, USA.

Sturkie, P. D. 1986. Heart: contraction, conduction, and electrocardiography. In Avian physiology (pp. 167-190). Springer, New York USA.

Sun, T., Levin, B. D. A., Guzman, J. J. L., Enders, A., Muller, D. A., Angenent, L. T., and Lehmann, J. 2017. Rapid electron transfer by the carbon matrix in natural pyrogenic carbon. Nature Communications 8(1):14873.

Teoh, R., Caro, E., Holman, D. B., Joseph, S., Meale, S. J., and Chaves, A. V. 2019. Effects of hardwood biochar on methane production, fermentation characteristics, and the rumen microbiota using rumen simulation. Frontiers in Microbiology, 10, 1534.

Terry, S. A., Ribeiro, G. O., Gruninger, R. J., Chaves, A. V., Beauchemin, K. A., Okine, E., and McAllister, T. A. 2019. A pine enhanced biochar does not decrease enteric CH4 emissions, but alters the rumen microbiota. Frontiers in Veterinary Science, 6, 308.

Trinder, P. 1969. Determination of glucose in blood using glucose oxidase with an alternative oxygen acceptor. Annals of clinical Biochemistry, 6(1), 24-27.

Warnick, G., Benderson, J., and Albers, J. J. 1982. Dextran sulfate-Mg2+ precipitation procedure for quantitation of high-density-lipoprotein cholesterol. Clinical chemistry, 28(6), 1379-1388.

Yang, H., Chen, Z. Q., and Ou, W. 2015. Microconchids from microbialites near the Permian-Triassic boundary in the Zuodeng

Section, Baise area, Guangxi Zhuang Autonomous Region, South China and their paleoenvironmental implications. Journal of Earth Science, 26(2), 157-165.

Zeweil, H. S. 1996. Enzyme supplements to diets growing Japanese quails. Egypt. Poult. Sci. J, 16, 535-557.

Zhao, R. S., Yuan, J. P., Jiang, T., Shi, J. B., and Cheng, C. G. 2008. Application of bamboo charcoal as solid-phase extraction adsorbent for the determination of atrazine and simazine in environmental water samples by high-performance liquid chromatography-ultraviolet detector. Talanta, 76(4), 956-959.

الملخص العربي

تأثير أضافة المستويات المتدرجة من البيوكار كمحفز للنمو على الأداء الإنتاجي والفسيولوجي لكتاكيت التسمين

أسامه أحمد الغليض[١]؛ عبد الحميد السيد عبد الحميد[٢] ؛ احمد حرفوش [٢] ؛ أسماء شوقي النجار[٢]

١- قسم إنتاج الدواجن - كلية الزراعه - جامعه الاسكندرية - مصر

٢- قسم الإنتاج الحيواني والداجني – كليه الزراعة – جامعة دمنهور- مصر

أجريت هذه الدراسة في وحدة بحوث الدواجن بمزرعه البستان، قسم الانتاج الحيواني والداجني، كلية الزراعة - جامعة دمنهور وكان الهدف منها تقييم التأثيرات الناتجة عن إضافة مستويات مختلفة متدرجة من البيوكار علي الصفات الانتاجية وخصائص الدم وميتابولزم الدهون والخصائص المضادة للأكسدة لكتاكيت اللحم. تم استخدام ٢١٦ من كتاكيت التسمين عشوائيا بداية من عمر أسبوع وحتى عمر ٦ اسابيع واستخدمت سته معاملات تجريبيه بكل معاملة ٣٦ طائر في سته مكررات بكل منها ٦ كتاكيت علي النحو التالي: المجموعة الاولى هى الضابطة (الكنترول) وكانت بدون إضافات؛ والمعاملات الخمسه الاخري تغذت على العليقه الأساسيه مع اضافه البيوكار بمستويات ١- 2- 4 - 6 و 8 % علي التوالي. أظهرت النتائج حدوث زيادة معنوية في وزن الجسم الحي ومعدل الزيادة في وزن الجسم مع تحسن في الكفاءة الغذائية والكفاءة الاقتصادية في المجموعات التي غذيت علي المستويات (١-٢-٤-٦ %) من البيوكار بالمقارنة بمجموعة الكنترول. كما أظهرت النتائج انخفاض معنوي في مستوي الدهون الكلية في الدم و الكوليسترول وكذلك انخفاض في مستوي LDL في المجموعات المغذاة علي مستويات البيوكار. لوحظ أيضا وجود زيادة في مستوي جلوكوز الدم وفي تركيز هرمونات الغدة الدرقية وأيضا تحسن في مستوي انزيمات الاكسدة المختلفة في سيرم الدم في المجموعات المغذاة علي البيوكار بالمستويات السابقه. وبالمثل تحسنت حالة مضادات التأكسد للطيور من واقع زيادة مستوى انزيم سوبر اكسيد ديسموتيز والجلوتاثيون بيروكسيديز والقدرة الكلية المضادة للأكسدة وتم تقدير الكفاءة الاقتصادية.

وقد خلصت نتائج الدراسة إلي أن إضافة المستويات من البيوكار(١-٢-٤-٦ %) كان لها تأثير ايجابي ومعنوي على الأداء الإنتاجي وقياسات الدم والخصائص المضادة للأكسدة لكتاكيت التسمين.