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Utilization of Natural Antioxidants to Improve the Growth Performance of Broiler Chicks

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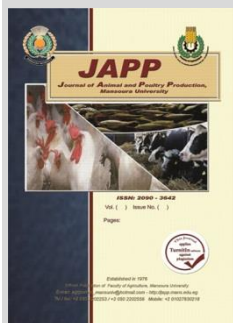


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ABSTRACT

A6-weeks study was designed to evaluate the growth performance, biochemical parameters, immune response and thyroid hormones of broiler chickens in response to feeding diets enriched with different types of natural antioxidants. Two hundred and fifty unsexed Arbor Acres broiler chicks were used in the present study. Day-old chicks were individually weighed and randomly divided into five dietary treatments with five replications of ten chicks each. Growth performance was measured. Serum concentrations of immunoglobulins (IgA, IgG and IgM)mg/dl, total antioxidant capacity(TAC) nmol/ml, malondialdehyde (MDA)U/ml/h and thyroid hormones: thyroxine(T4)ng/ml and triiodothyronine(T3)ng/ml were determined. Activity of superoxide dismutase(SOD)U/ml/h in blood serum was also measured. The results obtained revealed that feeding the natural antioxidants-supplemented diets to Arbor Acres broiler chicks positively affected ($P \leq 0.05$) their LBW, BWG and FCR at 6 weeks of age compared with control group. The FI of the supplemented groups of chicks was significantly lower ($P \leq 0.05$) than that of the control group, except the ascorbic acid-enriched group which consumed comparable amount of feed to that of the control birds. Feeding the natural antioxidants-fortified diets to broilers caused significant increases ($P \leq 0.05$) in serum levels of immunoglobulins (IgA, IgG and IgM), SOD and T3 but serum Alb level was not affected, and significantly improved ($P \leq 0.01$) serum concentration of TAC compared with the control birds. But serum T4 concentration was significantly higher ($P \leq 0.05$) in chicks fed Diet3 (contained 15% GP) than the control and other experimental groups. Based on the obtained results, it can be concluded that feeding natural antioxidants-enriched diets to broiler chicks have beneficial effects on their growth performance, immunity and antioxidant status.

Keywords: Natural Antioxidants, Growth Performance, Immunity, Antioxidant Status, Broilers.



INTRODUCTION

The usage of antibiotics as growth promoters all over the world represents a thoughtful hazard to humans, animals and the surrounding environment, so many studies have focused on looking for alternative nutritional strategies to maintain the health and growth performance of animals and poultry. There are several substances that can be used as natural growth promoters, alternatives to antibiotics. The alternative substances include probiotics, prebiotics, synbiotics, organic acids, phytochemicals, enzymes and others. These substances have the potential to beneficially affect the gastric health and growth performance by setting up and keeping up a well-balanced intestine microflora which secures the host creature against pathogenic microbes (Gadde et al., 2017).

Agricultural wastes are inexpensive, untraditional feedstuffs that can be used in animal and poultry diets to contribute in solving the problem of feed shortage, reducing the cost of the poultry ration and decreasing environmental pollution (El-Kerdawy, 1997). Grape pomace (GP) is one of these agricultural wastes. It is the dried by-product produced during wine manufacturing which consists of the skins, pulp, seeds and stems of grapes, and constitutes 20-25% of the grape weight (Dávila et al., 2017). The GP is a complex substrate composed of 30% neutral polysaccharides, 20% pectic substances, 15% insoluble proanthocyanidins, structural proteins, and phenolic compounds (Pinelo et al., 2006; González-Centeno et al., 2010; Devesa-Rey et al.,

2011; Minjares-Fuentes et al., 2014). It has been reported that GP is composed of 425 g of grape skin, 225 g of grape seeds, 249 g of stalks and other minor components (Nerantzis and Tataridis, 2006).

Some reports have indicated beneficial effects of dietary supplementation with ascorbic acid (vitamin C) on growth performance of chickens reared under heat stress (Kutlu and Forbes, 1993; Attia et al., 2011; Imik et al., 2012). Recently, Ijadunola et al. (2020) found that vitamin C was most effective than vitamin E or their combination in suppressing thermo-physiological responses of the broiler chickens but they detected no positive effects on their growth performance. Therefore, the present study was designed to investigate the effect of feeding diets containing different types of natural antioxidants (grape pomace, vitamin C and vitamin E) on growth performance, blood biochemical parameters, immune response and thyroid hormones of broiler chickens.

MATERIALS AND METHODS

The current study was conducted at the Village of Khammarah, Center of Itay El-Baroud, Beheira Governorate, Egypt. The blood analyses were undertaken at the Laboratory of Poultry Production Department, Faculty of Agriculture, Mansoura University, Egypt.

Experimental Birds and Diets: Two hundred and fifty unsexed Arbor Acres broiler chicks produced from an Egyptian commercial hatchery were utilized in the present study. Two

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basal diets were formulated mostly of yellow corn (YC), soybean meal (SBM) and corn gluten meal (CGM) to cover metabolizable energy (ME) values of 3000 and 3100 kcal ME/kg and crude protein (CP) concentrations of 23% and 21% CP during the starter (0-3 weeks of age) and grower (3-6 weeks of age) phases of growth, respectively. Thus, five experimental diets were composed as follows: a basal diet was compounded to serve as a control diet (Con.) and termed as Diet 1. Diets 2 and 3 contained 7.5 and 15% grape pomace (GP), respectively, and had similar ME and CP contents as did the control diet. Diets 4 and 5 were fortified (200 mg/kg) with vitamin C or vitamin E, respectively, and had similar ME and CP contents as did the control diet. The ingredient composition and calculated nutrient contents of the experimental diets are presented in Table 1.

Housing and Management: Day-old chicks were individually weighed and randomly divided into five experimental groups. Each experimental group of chicks contained five replications of ten chicks each. The ambient temperature around the chicks was maintained at 33°C during the first week and gradually decreased by 3°C weekly until the 4th week of age. The chicks were kept in naturally ventilated conventional floor pens and subjected to similar environmental, managerial and hygienic conditions. Chicks of each dietary treatment were fed their respective experimental diet (in mash form) and provided fresh water *ad libitum* throughout the entire experimental period (0-6 weeks of age).

Table 1. The Composition and chemical analyses of experimental diets fed to broilers from hatch to 6 weeks of age

Ingredients (%)↓	Starter diets (0-3 wk of age)					Grower diets (3-6 wk of age)				
	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
	Cont.	7.5% GP	15% GP	Vit. C 20mg/kg	Vit. E 20mg/kg	Cont.	7.5% GP	15% GP	Vit. C 20mg/kg	Vit. E 20mg/kg
YC, ground	61.70	57.10	49.0	61.68	61.68	70.50	61.50	54.5	70.48	70.48
SBM (44%CP)	18.50	9.70	7.50	18.50	18.50	10.0	8.50	5.0	10.0	10.0
CGM (60%CP)	15.00	20.50	21.60	15.00	15.00	15.0	16.0	18.0	15.0	15.0
Grape Pomace (GP)	-	7.50	15.0	-	-	-	7.5	15	-	-
Sunflower oil	-	0.30	2.00	-	-	-	2.0	3.0	-	-
Ground limestone	2.00	2.00	2.00	2.00	2.00	1.70	1.70	1.7	1.70	1.70
Dicalcium phosphate	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80
Vit. & Min. Premix [§]	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Common salt (NaCl)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
DL-Methionine	-	-	-	-	-	-	-	-	-	-
L-Lysine-HCl	0.40	0.50	0.50	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Vit. C	-	-	-	0.02	-	-	-	-	0.02	-
Vit. E	-	-	-	-	0.02	-	-	-	-	0.02
Total	100	100	100	100	100	100	100	100	100	100
Calculated analyses:	As fed basis (NRC,1994)									
ME, kcal/kg	3052	3049	3043	3051	3051	3157	3162	3131	3157	3157
Crude protein, %	23.6	23.13	22.99	23.6	23.6	20.07	20.09	20.03	20.07	20.07
Crude fiber, %	2.85	4.17	5.82	2.85	2.85	2.45	4.12	5.71	2.45	2.45
Ether extract, %	2.87	3.71	5.76	2.87	2.87	3.13	5.46	6.86	3.13	3.13
Lysine, %	1.122	1.10	1.03	1.12	1.12	0.92	0.91	0.86	0.92	0.92
Meth., %	0.45	0.48	0.48	0.45	0.45	0.41	0.42	0.43	0.41	0.41
Meth. + Cyst., %	0.85	0.89	0.89	0.85	0.85	0.77	0.77	0.78	0.77	0.77
Total phosphorus, %	0.70	0.67	0.64	0.70	0.70	0.67	0.65	0.62	0.67	0.67
Av. phosphorus, %	0.46	0.44	0.43	0.46	0.46	0.44	0.43	0.42	0.44	0.44
Calcium, %	1.20	1.21	1.22	1.20	1.20	1.10	1.10	1.10	1.10	1.10

[§] Each two kg of the premix contained: Vit. A(10,000,000IU), Vit.D₃(2,500,000IU), Vit.E(30g), Vit.K₃(3g), Vit.B₁(1.0g),Vit.B₂ (5 g), Vit. B₅ (10 g), Vit. B₆ (2.5 g), Vit. B₁₂ (20 mg), Niacin (32.5 g), Folic acid (1.0 g), Biotin (100 mg), Fe (42 g), Zn (60 g), Cu (10 g), Mn (75 g), I (1.5 g), Se (300 mg), BHT (600 mg), Propylgalate (400 mg) and Ca CO₃ up to 2 kg. ↓: YC= Yellow corn, SBM= Soybean meal and CGM= Corn gluten meal.

Growth performance: Broiler chicks in all treatment groups were weighed weekly during the whole experimental period. Live body weight (LBW) of chicks was recorded in the morning before offering feeds, on a replicate group basis. Similarly, feed intake (FI) of each replication of chicks was determined weekly. Thus, body weight gain (BWG) and feed conversion ratio (FCR) for each replication of birds were estimated. The FCR of the whole experimental period was calculated by dividing total FI for each replication by its total BWG.

Blood Parameters: At the end of the study (6 weeks of age), five blood samples for each treatment were collected of the slaughtered birds in clean non-heparinized test tubes. Serum was separated by centrifugation at 3000 rpm for 10 minutes and stored at -20C until analysis. Blood serum concentrations of total protein (TP), albumin (Alb), globulin (Glo), total lipids (TL), triglycerides (Tri), total cholesterol (TC), high-

density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), immunoglobulins (IgA, IgG and IgM), total antioxidant capacity (TAC), malondialdehyde (MDA) and thyroid hormones: thyroxin (T4) and triiodothyronine (T3) were determined. Activity of alanine aminotransferase (ALT), aspartate aminotransferase (AST) and superoxide dismutase (SOD) were also measured in blood serum. All blood serum parameters (except hormones) were determined by commercial kits obtained from Spectrum diagnostic kits, Spect. Corp. Biotech. S.A.E., Egypt.

Statistical analysis:

Data were analyze dutilizing one way investigation of fluctuation (ANOVA) of the common direct demonstrate (GLM) method ofthe Factual Investigation Framework (SAS,2 00).The noteworthy contrasts among implies of diverse medicat ions were distinguished byDuncan's modern numerous run test (Duncan, 1955), at 0.05 level of centrality

RESULTS AND DISCUSSION

Growth Performance of Chicks:

The effects of feeding natural antioxidants-enriched diets on growth performance of broiler chicks are presented in Table 2. Initial live body weight (LBW) of chicks ranged from 44.6 to 46.0 g with no significant differences ($P>0.05$) among different experimental groups. At the end of the study (6 weeks of age), chicks fed the natural antioxidants-supplemented diets displayed significantly heavier ($P\leq 0.05$) final LBW at 6 weeks old than the control group. Means of final LBW for birds fed the diets supplemented with 7.5%

grape pomace (GP), 15% GP, 200 mg/kg ascorbic acid and 200 mg/kg vitamin E, respectively were 2.012, 2.016, 2.029, 2.021 kg compared with 1.915 kg for the control chicks. Similarly, feeding the natural antioxidants-diets positively affected ($P\leq 0.05$) the total body weight gain (BWG) and feed conversion ratio (FCR) of chicks compared with the control group. The FI of the supplemented groups of chicks was significantly lower ($P\leq 0.05$) than that of the control group, except the ascorbic acid-enriched group which consumed comparable amount ($P>0.05$) of feed to that of the control birds.

Table 2. Effects of feeding natural antioxidants-supplemented diets on growth performance of broiler chicks from hatch to 6 weeks of age

Treatments	Diet 1 Cont.	Diet 2 7.5% GP	Diet 3 15% GP	Diet 4 Vit. C 200 mg/kg	Diet 5 Vit. E 200 mg/kg	SEM	Significance
Initial LBW, (g)	46.0	44.6	45.0	44.6	45.4	0.54	NS
Final LBW, (kg)	1.915 ^b	2.012 ^a	2.016 ^a	2.029 ^a	2.021 ^a	1.54	*
Total BWG, (kg)	1.869 ^b	1.967 ^a	1.971 ^a	1.985 ^a	1.976 ^a	1.53	*
Total FI, (kg)	3.291 ^a	3.187 ^b	3.185 ^b	3.225 ^{ab}	3.179 ^b	3.30	*
FCR, (kg:kg)	1.76 ^a	1.62 ^b	1.62 ^b	1.63 ^b	1.61 ^b	0.02	*

Means within the same row having different superscripts differ significantly ($P\leq 0.05$). SEM: Standard error of the means. NS: Not significant. *: Significant at $P\leq 0.05$.

Such beneficial effects of feeding the natural antioxidants-enriched diets on LBW, BWG and FCR may be due to an improvement in the digestion, absorption and utilization of nutrients induced by the tested natural antioxidants (GP, ascorbic acid and Vit. E), as shown in Table 2. It is well known that most growth promoters act by modifying intestinal flora, especially, targeting gram-negative bacteria, which are associated with poorer health and performance of poultry. The beneficial effects of feeding the GP-containing diets on growth performance of chicks may be exerted by the active components in GP since it is a rich source of Polyphenols that have the capacity to act as powerful antioxidants. Our results are in agreement with the findings of Pascariu *et al.* (2017) and Hajati *et al.* (2015), who found that the whole grape pomace supplementation (10 or 20 g/kg diet) to Cobb 500 broiler diets positively affected the means of LBW, BWG and FCR of broilers as compared to the control group. Selvam *et al.* (2017) reported that the supplementation of vitamin E to the birds subjected to high stocking density beneficially affected BWG, FCR and European production efficiency factor. Ismail *et al.* (2014) who found that dietary enrichment with vitamin E resulted in better growth performance of broiler chickens when compared to their control counterparts. Similarly, Sahin and Kucuk (2001) reported that inclusion of vitamin E in the diet of Japanese quails reared under heat stress caused an improvement in their growth performance. Amer *et al.* (2021) found that an increase in the final LBW, total BWG, total FI, and the relative growth rate of broiler chickens in response to feeding diets containing safflower oil and vitamin C. They found that vitamin C supplementation increased the apparent ileal digestibility of lysine, threonine, tryptophan, arginine, and valine. They also reported that dietary supplementation of safflower oil and vitamin C improved the histology and various morphological characteristics of the intestines. On the other hand, Aditya *et al.* (2018) and Ebrahimzadeh *et al.* (2018) detected no positive effects on growth performance of broiler chicks due to feeding dried GP-containing diets.

Biochemical Parameters:

Table 3 illustrates biochemical serum parameters of broiler chicks as affected by feeding natural antioxidant-supplemented diets from hatch to 6 weeks of age. As shown in the Table 3, feeding the natural antioxidants-fortified diets to broilers caused significant increases ($P\leq 0.05$) in serum levels of TP, Glo, HDL-C compared with the control birds but serum Alb concentration was not affected. Chicks fed the supplemented diets exhibited significantly lower ($P\leq 0.05$) serum concentration of Tri and activity of AST and ALT ($P\leq 0.01$) in blood serum than those of the control group. Also significant reductions ($P\leq 0.05$) in serum concentrations of TC were displayed by chicks fed the diet containing 15% GP and the diet enriched with ascorbic acid (200 mg per kg) and in serum level of LDL-C of chicks fed the diet containing 15% GP compared with the control and other experimental groups, with no significant differences among them.

The increased concentrations of serum total Glo of broilers due to feeding the natural antioxidants-fortified diets (Table 3) are indication to an improvement in their immune status. This result might be attributed to the antioxidant properties of the investigated feed additives. The detected reductions in serum concentrations of TC due to feeding the diet containing 15% GP and the diet enriched with ascorbic acid and in serum level of LDL-C in response to feeding the diet containing 15% GP are in harmony with the findings of Konca *et al.* (2009) that dietary ascorbic acid supplementation to male turkeys, reared under summer conditions, caused a quadratic decrease in serum levels of TC, LDL-C and activity of AST in blood serum. But they also observed that serum concentrations of Tri, HDL-C, TP, Alb, Glo, urea, uric acid, and activity of ALT, lactate dehydrogenase and alpha amylase were not influenced by feeding the vitamin C-supplemented diets. In addition, Imik *et al.* (2013) found that dietary supplementation with vitamin C to heat stressed broilers did not significantly alter serum levels of glucose, TP, Alb, Glo, Tri, TC, lipoproteins, and electrolytes (Na^+ , K^+ and Cl^-), and serum activity of liver enzymes.

Table 3. Blood Biochemical parameters at 6-wk-old broiler chicks as affected by feeding natural antioxidant

Parameters	Diet 1 Cont.	Diet 2 7.5% GP	Diet 3 15% GP	Diet 4Vit. C 200 mg/kg	Diet 5Vit. E 200 mg/kg	SEM	Significance
TP, g/dl	3.94 ^b	4.61 ^a	4.80 ^a	4.69 ^a	4.68 ^a	0.20	*
Alb, g/dl	2.26	2.55	2.48	2.53	2.61	0.11	NS
Glo, g/dl	1.68 ^b	2.06 ^a	2.32 ^a	2.16 ^a	2.07 ^a	0.11	*
TC, mg/dl	179.2 ^a	168.0 ^{ab}	163.8 ^b	162.9 ^b	166.9 ^{ab}	3.9	*
Tri, mg/dl	155.7 ^a	142.2 ^b	138.1 ^b	131.7 ^b	133.0 ^b	3.68	*
HDL-C, mg/dl	48.04 ^b	54.27 ^a	49.63 ^a	50.13 ^a	50.75 ^a	3.70	*
LDL-C, mg/dl	100.0 ^a	95.32 ^a	86.62 ^b	96.48 ^a	99.63 ^a	2.89	*
AST, U/dl	69.64 ^a	56.15 ^b	51.47 ^b	48.68 ^b	51.70 ^b	3.20	*
ALT U/dl	21.33 ^a	13.80 ^{bc}	13.43 ^c	16.59 ^b	16.06 ^{cb}	0.92	**

Means within the same row having different superscripts differ significantly ($P \leq 0.05$). SEM: Standard error of the means. NS: Not significant. *: Significant at $P \leq 0.05$. **: Significant at $P \leq 0.01$.

Table 4 summarizes immune response, antioxidant status and thyroid hormones of broiler chicks as influenced by feeding natural antioxidant from hatch to 6 weeks of age. As shown in Table 4, feeding the natural antioxidants-fortified diets to broilers produced significant increases ($P \leq 0.05$) in serum levels of immunoglobulins (IgA, IgG and IgM), SOD and T₃, and significantly improved ($P \leq 0.01$) serum

concentration of TAC compared with the control birds. But serum T₄ concentration was significantly higher ($P \leq 0.05$) in chicks fed the diet containing 15% GP than the control and other experimental groups, with no significant differences among them. Chicks fed the supplemented diets exhibited significantly lower ($P \leq 0.05$) serum levels of MDA and T₄: T₃ ratio than those of the control group.

Table 4. Immune response, antioxidant status and thyroid hormones of 6-wk-old broiler chicks as affected by feeding natural antioxidant

Parameters	Diet 1 Cont.	Diet 2 7.5% GP	Diet 3 15% GP	Diet 4Vit. C 200 mg/kg	Diet 5Vit. E 200 mg/kg	SEM	Significance
IgG, mg/dl	437.1 ^b	496.9 ^a	494.7 ^a	496.4 ^a	496.4 ^a	11.55	*
IgM, mg/dl	167.4 ^b	197.9 ^a	203.0 ^a	198.7 ^a	194.4 ^a	7.91	*
IgA, mg/dl	103.3 ^b	133.6 ^a	136.2 ^a	146.2 ^a	138.9 ^a	4.91	*
TAC, nmol/ml	1.11 ^d	1.79 ^c	1.87 ^{bc}	2.15 ^{ab}	2.26 ^a	0.11	**
MDA, U/ml/h	42.38 ^a	22.21 ^b	20.09 ^b	16.39 ^b	17.91 ^b	1.83	*
SOD, U/ml/h	61.84 ^b	79.90 ^a	83.52 ^a	92.66 ^a	87.84 ^a	4.60	*
T ₄ , ng/ml	19.99 ^b	22.72 ^{ab}	24.20 ^a	22.18 ^{ab}	21.69 ^{ab}	1.09	*
T ₃ , ng/ml	3.64 ^b	4.52 ^a	4.91 ^a	4.43 ^a	4.47 ^a	0.22	*
T ₄ : T ₃	5.51 ^a	5.01 ^b	4.93 ^b	5.002 ^b	4.86 ^b	0.12	*

Means within the same row having different superscripts differ significantly ($P \leq 0.05$). SEM: Standard error of the means. *: Significant at $P \leq 0.05$. **: Significant at $P \leq 0.01$.

The MDA is one of the lipid peroxidation by-products that is frequently used as a biomarker for lipid peroxidation (Bacou *et al.*, 2021). In the lipid peroxidation process, reactive oxygen species predominantly attack the polyunsaturated fatty acids present in the cellular membranes, leading to membrane disorder and cell damage (Ostalowska *et al.*, 2006; Bacou *et al.*, 2021). The observed increases in serum concentrations of immunoglobulins (IgA, IgG and IgM), SOD and TAC, and the reduced MDA levels of broilers fed the diets enriched with the natural antioxidants, tested herein (GP, ascorbic acid and vitamin E), are indications of high immune response and good health status of birds (Table 4). Our results harmonize with the findings of Habibian *et al.* (2014), who described that nourishing vitamin E-supplemented diets produced an improvement in the primary and secondary antibody response of broiler chickens, reared under thermo-neutral or heat stress conditions. Also, Jena *et al.* (2013) demonstrated that feeding diets enriched with vitamin C and vitamin E singly or in combination to broiler breeders caused a significant decrease in erythrocyte MDA level and significantly increased activity of SOD and CAT in blood plasma compared with the control hens. They suggested that the observed reduction in erythrocyte MDA concentration in hens fortified with vitamin C and vitamin E might have been occurred by inhibiting the lipid peroxidation

in erythrocyte membranes *via* antioxidant properties of both vitamins. The observed increase in serum concentration of SOD and decrease in serum MDA, obtained here, due to feeding natural antioxidants (GP, ascorbic acid and vitamin E) concur also with those reported by Ebrahimzadeh *et al.* (2018). They reported that broiler chickens fed GP-containing diets displayed higher levels of SOD and lower MDA concentration than did the control ones. Recently, Amer *et al.* (2021) found that serum levels of SOD, CAT and reduced glutathione (GSH), and IgA were significantly increased in broiler chickens fed the vitamin C-supplemented diets compared with the control group. However, Adenkola and Angani (2017) stated that vitamin C administration *via* drinking water to broiler chickens led to significant reductions in serum MDA concentration and in activity of serum CAT, SOD and glutathione peroxidase compared with their control counterparts. In conclusion, feeding natural antioxidants-enriched diets have beneficial effects on the growth performance, immunity and antioxidant status of broiler chickens.

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إستعمال مضادات الأكسدة الطبيعية لتحسين أداء النمو في كتاكيت اللحم إبراهيم شعبان منقولة ، محمود حسن ربيع ، هيام محمد أبو المعاطي وأسما شوقى النجار قسم إنتاج الدواجن ، كلية الزراعة ، جامعة المنصورة ، مصر

تم تصميم دراسة مدتها 6 أسابيع لتقييم أداء النمو ومقاييس الدم والإستجابة المناعية وهرمونات الدرقية لكتاكيت اللحم عقب التغذية على علائق مدعمة بأنواع مختلفة من مضادات الأكسدة الطبيعية. إستخدم في هذه الدراسة عدد 250 ككتوتا (من كلا الجنسين) من سلالة الأربور أكرز لكتاكيت اللحم. تم وزن الكتاكيت عمر يوم فرديا وتوزيعها عشوائيا على 5 معاملات غذائية بكل منها 5 مكررات متساوية. تم تكوين 5 علائق تجريبية لفترة البادئ (3 أسابيع الأولى من العمر) و5 أخري الفترة النامي (3-6 أسابيع) وهي: عليقة قاعدية لتمثل عليقة الضبط وسميت العليقة 1، واحتوت العليقتين 2، 3 على ثقل العنبر بمعدل 7.5، 15%، وتمثلت مع عليقة الضبط (الكنترول) في محتواها من الطاقة القابلة للتمثيل والبروتين الخام. وتم تدعيم العليقتين 4، 5 بـ 200 ملج/كج من حامض الأسكوربيك وفيتامين E، على التوالي، وتمثلت مع عليقة الضبط (الكنترول) في محتواها من الطاقة القابلة للتمثيل والبروتين الخام. تم تربية جميع الكتاكيت في عنابر أرضية تقليدية مهواة طبيعيا وتعرضت لظروف بيئية ورعائية وصحية متماثلة. و غذيت كتاكيت كل معاملة على الغذاء التجريبي الخاص بها وتم إمدادها بالماء الطازج بحرية طوال فترة الدراسة (0-6 أسابيع). وتم قياس أداء النمو في صورة: وزن الجسم الحي، إستهلاك الغذاء، زيادة وزن الجسم، ومعدل التحويل الغذائي. تم تقدير محتويات سيرم الدم من البروتين الكلي، والألبومين، والجلوبولين، والجليسريدات الثلاثية، والكوليستيرول الكلي، والكوليستيرول الليبوبروتيني مرتفع الكثافة، والكوليستيرول الليبوبروتيني منخفض الكثافة، والجلوبولينات المناعية (IgA, IgG and IgM)، القدرة الكلية لمضادات الأكسدة، ومركب المالون داي ألدهيد (MDA) وهرمونات الدرقية (T3 and T4). كما تم قياس نشاط إنزيمات الكبد (AST and ALT) وإنزيم سوبرأوكسيد ديسميوتيز (SOD) في سيرم الدم. أوضحت النتائج المتحصل عليها أن تغذية كتاكيت اللحم على العلائق المدعمة بمضادات الأكسدة الطبيعية أحدثت تحسنا إيجابيا في كل من وزن الجسم الحي، والزيادة المكتسبة في وزن الجسم، ومعدل التحويل الغذائي في نهاية الدراسة مقارنة بمجموعة الضبط. بينما كان إستهلاك الغذاء للمجموعات المعاملة باستثناء المجموعة المدعمة فيتامين ج أقل مغنويا عنه لمجموعة الضبط. أحدثت تغذية كتاكيت اللحم على العلائق المدعمة بمضادات الأكسدة الطبيعية زيادة مغنوية في تركيزات سيرم الدم من البروتين الكلي، والجلوبولين، والكوليستيرول الليبوبروتيني مرتفع الكثافة، والجلوبولينات المناعية، وهرمون T3، ونشاط إنزيم الـ SOD، كما تحسنت القدرة الكلية لمضادات الأكسدة مقارنة بمجموعة الضبط ولكن لم يتأثر مستوى الألبومين في سيرم الدم. سجلت الكتاكيت التي غذيت على العليقة 3 (15% ثقل العنبر) زيادة مغنوية في تركيز هرمون الـ T4 عن باقي المجموعات التجريبية الأخرى. كما سجلت الطيور المدعمة بالمواد المختبرة انخفاضا مغنويا في مستويات سيرم الدم من الجليسيريدات الثلاثية، مركب الـ MDA، ونشاط إنزيمي الـ ALT and AST، ونسبة الـ T4: T3 عن مجموعة الضبط. كما سجلت الكتاكيت التي غذيت على العليقة 3 (15% ثقل العنبر) أو العليقة 4 (المدعمة بحامض الأسكوربيك) نقصا مغنويا في تركيزات الكوليستيرول الكلي مقارنة بمجموعة الضبط. أيضا سجلت الكتاكيت التي غذيت على العليقة 3 (15% ثقل العنبر) نقصا مغنويا في مستوى الكوليستيرول الليبوبروتيني منخفض الكثافة مقارنة بباقي المجموعات التجريبية. ويمكن أن نستخلص من تلك النتائج أن تغذية كتاكيت اللحم على علائق مدعمة بمضادات الأكسدة الطبيعية لها تأثيرات إيجابية على أداء النمو والمناعة والقدرة الكلية لمضادات الأكسدة بالجسم.