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Effects of Natamycin on Growth Performance, Serum Biochemical Parameters and Antioxidant Capacity in Broiler Chickens

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ABSTRACT

A total of 360 broilers were fed with basal diets (CON group), basal diets supplemented with 10 or 50 mg/kg natamycin (T1 or T2 group) for 42d, respectively. The results showed that alkaline phosphatase in T2 group was significantly decreased at 21d, blood urea nitrogen and alanine aminotransferase were significantly increased compared to CON group at 42d in broilers. Serum globulin content (21d) and total protein content (42d) were lower in T2 group than that of CON group. Serum total antioxidant capacity was higher and malondialdehyde content was lower in T1 group than that of CON group at 21d. Serum glutathione peroxidase enzyme activity was significantly increased in T1 group compared to CON group at 42d. Malondialdehyde content of liver in T1 group was lower than that of CON group. These results suggested that dietary supplementation of 10 mg/kg natamycin had a positive influence in broilers.

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HA provided guidance and help in this writing. JZ and LZ assisted in the experiments. TW provided research platforms and other help for this article.

Key words
Antioxidant, Broiler, Growth performance, Natamycin, Serum biochemical parameters.

INTRODUCTION

In recent years, contamination of feed mold is very common during production, processing, and storage, which has become a worldwide problem in poultry and livestock production and feed industry. The consumption of multiple mycotoxin contaminated diets may lead to hematological, biochemical and liver functioning abnormalities and restrain the growth of animals (Rezar *et al*., 2007; Gowda *et al*., 2008). The most potent dietary approach to prevent fungi growth in poultry is the use of preservatives. Many chemical preservatives have been used to inhibit the fungi growth in the feed industry (Jeff-Agboola *et al*., 2012). The negative consumer perception of chemical preservatives drives attention toward natural alternatives. It is essential to search for new and safer feed additives that can preserve feed for a long time. As a consequence, the use of natural antimicrobials from a wide variety of natural sources has begun to be explored (Tiwari *et al*., 2009; Lucera *et al*., 2012; Ollé Resa *et al*., 2014).

Natamycin is a polyene macrolide antibiotic product of Streptomyces species, produced during fermentation, in particular from actinomycete *Streptomyces natalensis* and related species (Hanušová *et al*., 2010; Roberts *et al*., 2011). It is an effective and natural food preservative which is widely used to inhibit fungi growth in food industry (Dzigbordi *et al*., 2013; Arima *et al*., 2014). Its mechanism of action is binding to sterols (principally ergosterol) in the fungal cell membrane, thus disturb the membrane morphology and impair its physiology, resulting in enhanced permeability to protons and leakage of internal constituents such as K^+, Ca^{2+} and PO_4^{3-}. Bacteria lack sterols in their membranes, therefore, they are insensitive to natamycin (Bossche *et al*., 1995; Balaguer *et al*., 2013). Natamycin has been considered as a GRAS (generally recognized as safe) product by the FDA (Koontz *et al*., 2003; Cong *et al*., 2007) and also registered as a natural preservative by the European Union (EECN235) (Balaguer *et al*., 2014). The use of natamycin as a natural preservative has been approved in more than sixty countries (Thomas and Delves-Broughton, 2001; Delves-Broughton *et al*., 2005). Qi *et al*. (1998) reported that the application of natamycin in the poultry feed industry could effectively control the disease caused by *Aspergillus*. FDA approved that diets supplemented with natamycin in feed could prevent fungal disease in poultry. Hu *et al*. (2015) have repoted that 5-20 mg/kg natamycin supplementation could inhibit fungi growth in feed.

The quantity of the new additive incorporated to feed shall be limited to the appropriate levels and it is necessary to determine the effects of feed preservatives by using different dose levels in the living organisms (Fajardo *et al*., 2010). Serum biochemical parameters such as ALT activity provide a sensitive and specific measure of hepatic

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function or injury (Abbès *et al*., 2006). The liver is a vital organ present in animals that is necessary for survival, and is the main metabolic organ for feed additives. However, limited information is available concerning the use of natamycin in poultry industry. Thus, the aim of this study was to investigate the effects of natamycin, as a feed preservative, on growth performance, serum biochemical parameters and antioxidant capacity in broilers.

Table I.- Ingredients and nutrient composition of the basal diets.

Ingredients (%)	1 to 21 d	22 to 42 d
Corn	56.02	62.67
Soybean meal	12.20	1.30
Wheat middling	7.00	4.00
Corn gluten meal	8.00	9.50
Cottonseed meal	7.50	8.50
Extruded soybean	5.10	10.20
Limestone	1.55	1.64
$CaHPO_4$	1.19	0.75
L-Lysine	0.33	0.39
DL-Methionine	0.08	0.03
L-Threonine	0.03	0.02
Premix†	1.00	1.00
Total	100.00	100.00
Calculation of nutrients		
ME (MJ/kg)	12.46	13.03
Crude protein (%)	21.10	19.80
Calcium (%)	0.95	0.87
Available phosphorus (%)	0.35	0.28
Lysine (%)	1.08	1.02
Methionine (%)	0.45	0.42
Methionine + Cysteine (%)	0.84	0.79

†Premix provided per kilogram of diet: Fe, 60 mg; Cu, 7.5 mg; Zn, 65 mg; Mn, 110 mg; I,1.1 mg; Se, 0.4 mg; VA, 10000 IU; VD_3, 3000 IU; VE, 20 mg; VK, 1.3 mg; VB_1, 2.2 mg; VB_2, 10 mg; VB_3, 10 mg; Choline chloride, 400 mg; VB_5, 50 mg; VB_6, 4 mg; Biotin, 0.04 mg; VB_{11}, 1 mg; VB_{12}, 1.013 mg.

MATERIALS AND METHODS

Materials and reagents

In the present study, the commercial formaulation of natamycin (Delvocid which has 2% natamycin as an active ingredient) was used. It was provided by LvKang Biotechnology Co. Ltd., Fujian, China. Ethanol and glacial acetic acid of analytical grade were purchased from the Shanghai Chemical Agents Company, China.

Experimental design, birds and management

A total of 360 one-day-old healthy Arbor Acres (AA) broiler chickens (half male and half female) were procured from a local hatchery. All birds were randomly divided into 3 treatments and each group had 6 replicates. Each replicate contained 20 broiler chickens. Broilers were fed basal diets either without supplementation of natamycin (CON group), or with natamycin at different levels of 10 mg/kg (T1 group), or 50 mg/kg (T2 group). The composition of the basal diets and nutrient levels for the starter (1 to 21d) and grower phases (22 to 42d) were formulated to meet NRC (1994) nutrient requirements (Table I). All birds were placed in wire cages in a 3-level battery and housed in an environmentally controlled room maintained at 35°C during 1 to 14 d and then the environmental temperature was gradually decreased to 22°C, after which it was maintained at room temperature and kept constant till the end of the experiment. The light was provided 23 h per day. Broilers were allowed to consume mash feed and water *ad libitum*. All broilers were vaccinated against infectious bursal disease and Newcastle disease. The whole experiment was conducted for 42 d of age.

This project was done according to the guidelines for animal experiments at the National Institute of Animal Health and performed at the Experimental Unit of the Nanjing Agricultural University in Nanjing, P. R. China.

Sample collection and procedures

Body weight (BW) of each broiler and feed consumption of each replicate were recorded starting from 1d of age. Body weights of broilers were recorded at 1, 21 and 42 d of age. Feed was withdrawn for 12 h and water was provided for *ad libitum* drinking before weighing at 21 and 42 d of age. Growth performance of broilers was evaluated in terms of average daily feed intake (ADFI), average daily gain (ADG) and F/G. F/G was calculated as ADFI dividing by corresponding ADG.

Two broilers per replicate (n=12, half male and half female) were randomly selected from all treatments in the morning of 21 and 42 d of the experiment. The BW of each bird was measured followed by blood samples taken from wing vein into nonheparinized tube. Blood samples were subsequently centrifuged at 1500×*g* at 4°C for 10 min after standing 20 min at room temperature and serum samples were preserved at -20°C for further assay analysis.

At the end of the experiment (d 42), 12 broilers were selected randomly from each treatment (2 from each replicate) and slaughtered by severing the carotid artery and jugular vein, and eviscerate to obtain liver tissue samples manually. The collected liver tissue samples were frozen at -80°C for further analysis.

Table II.- Sequences for real-time PCR primers.

Gene†	GeneBank ID	Primer sequence (5'→3')	Product size (bp)
β-Actin	NM_205518.1	TGCTGTGTTCCCATCTATCG TTGGTGACAATACCGTGTTCA	150
Nrf2	NM_205117.1	GATGTCACCCTGCCCTTAG CTGCCACCATGTTATTCC	215
Cu/ZnSOD	NM_205064.1	CCGGCTTGTCTGATGGAGAT TGCATCTTTTGGTCCACCGT	124
MnSOD	NM_204211.1	AGGAGGGGAGCCTAAAGGAGA CCAGCAATGGAATGAGACCTG	214
CAT	NM_001031215.1	GGTTCGGTGGGGTTGTCTTT CACCAGTGGTCAAGGCATCT	211
GPx	NM_001277853.1	GACCAACCCGCAGTACATCA GAGGTGCGGGCTTTCCTTTA	205

†Nrf2, nuclear factor erythroid 2-related factor 2; Cu/ZnSOD, copper/zinc superoxide dismutase; MnSOD, manganese superoxide dismutase; CAT, catalase; GPx, glutathione peroxidase.

Serum biological parameters and antioxidant enzymes in broilers

The serum parameters including blood urea nitrogen (BUN), glucose (GLU), total bilirubin (TBIL), total protein (TP), albumin (ALB) and globulin (GLB) were determined by using kits purchased from Shanghai Kehua Bioengineering Co. Ltd., China. The activities of alkaline phosphatase (ALP), alanine aminotransferase (ALT), aspartate aminotransferase (AST), total antioxidant capacity (T-AOC), total superoxide dismutase (T-SOD), glutathione peroxidase (GSH-Px) and malondialdehyde (MDA) levels were measured by using kits purchased from Nanjing Jiancheng Bioengineering Institute (Nanjing, P. R. China) according to the methods followed by Zhang *et al*. (2009).

Liver antioxidant enzyme activities in broilers

Liver tissue samples (0.5 g) were used to prepare the liver homogenate. The liver tissue samples were diluted with 0.9% normal saline (1:9, w/v) and homogenized by using a PRO200 homogenizer (Aoran Technology Limited USA) and centrifuged using a 5804R desktop high-speed refrigerated centrifuge (Eppendorf Company, Germany) was used to obtain supernatants at 1200×*g* at 4°C for 10 min. Protein content, T-AOC level, antioxidant enzyme activities including T-SOD, GSH-Px and MDA content of the liver homogenate were determined by using kits purchased from Nanjing Jiancheng Bioengineering Institute (Nanjing, P. R. China) according to the methods followed by Zhang *et al*. (2009).

Real-time polymerase chain reaction (PCR) analysis

The total RNA was isolated from the frozen liver tissue by using Trizol reagent (Takara Bio. Inc., Dalian, China) and then reverse-transcribed by using the Perfect Real Time SYBR PrimeScriP kit (TaKaRa). Then the cDNA samples were amplified by quantitative real-time PCR with SYBR Premix Ex *Taq*II kit (Takara Bio, Inc., Dalian, China). The amplification was performed in triplicate in a total volume of 20 µL, including 10 µL SYBR Premix Ex Taq (2X), 0.4 µL each of forward and reverse primers, 0.4 µL ROX reference dye (50X; Life Technologies, Grand Island, New York), 6.8 µL double-distilled H_2O, and 2 µL cDNA template. The reaction proceeded in an ABI 7300 system (Applied Biosystems, Foster City, CA) as follows: 95 °C for 30 s, 40 cycles of 95 °C for 5 s, and 60 °C for 30 s. The primer sequence of each target gene is shown in Table II. The mRNA expression level of each target gene was calculated using the $2^{-\Delta\Delta Ct}$ method, in which $\Delta Ct = Ct_{\text{target gene}} - Ct_{\beta\text{-actin}}$ and $\Delta\Delta Ct = \Delta Ct_{\text{samples in all groups}} - \Delta Ct_{\text{the mean of the control group}}$. The β-actin gene was amplified as an internal standard in the present study.

Statistical analysis

Experimental data were analyzed using SPSS statistical package (version 16.0 for Windows; SPSS Inc., Chicago, IL, USA). Multiple comparisons between groups were performed by one-way ANOVA supplemented with Duncan's multiple comparison. Results were expressed as treatment means with their pooled standard error (SE), which were expressed as means ± SE. Significance level was accepted at p lower than 0.05.

RESULTS

Growth performance in broilers

The results of the present study showed that during the experimental periods of 1 to 21 d, or 22 to 42 d, or the

overall period of 1 to 42d, growth performance was not influenced ($P > 0.05$) by treatments in broilers (Table III).

Table III.- Effects of natamycin on the growth performance in broilers†.

Item‡	CON	T1	T2
1 to 21 d			
ADFI (g)	52.07±1.34	51.56±0.92	52.59±2.17
ADG (g)	34.90±0.93	35.16±0.57	34.97±0.64
F/G	1.50±0.05	1.47±0.01	1.50±0.05
22 to 42 d			
ADFI (g)	123.68±4.74	130.35±12.16	135.64±4.81
ADG (g)	57.80±0.64	60.51±1.24	61.66±1.74
F/G	2.14±0.06	2.14±0.16	2.20±0.08
1 to 42 d			
ADFI (g)	93.85±4.30	96.23±5.38	99.67±4.81
ADG (g)	46.33±0.37	47.50±0.75	47.62±0.59
F/G	2.02±0.09	2.02±0.09	2.09±0.09

†Data are means of 6 replications of 20 chicks each. Values are mean ± SE. ‡ADFI, average daily feed intake, ADG, average daily gain, F/G, feed conversion rate (ADFI/ADG); T_1, Broilers were fed basal diets with natamycin of 10 mg/kg; T_2, Broilers were fed basal diets with natamycin of 50 mg/kg.

Table IV.- Effects of natamycin on serum biochemical indicators in broilers†.

Item‡	CON	T1	T2
21 d			
BUN (mmol/L)	0.53±0.08	0.52±0.03	0.49±0.05
GLU (mmol/L)	14.99±0.83	15.00±0.64	15.14±0.76
TBIL (μmol/L)	4.24±0.24	3.47±0.42	4.27±1.06
ALP (×10² U/L)	13.96± 0.67^{a}	13.41± 0.64^{ab}	11.91± 0.42^{b}
ALT (U/L)	12.40±0.94	8.90±1.07	11.96±1.59
AST (U/L)	62.37±5.67	63.93±4.37	62.91±3.31
42 d			
BUN (mmol/L)	0.52±0.02^{b}	0.56±0.02^{ab}	0.60±0.01^{a}
GLU (mmol/L)	15.98±1.32	12.90±0.88	13.53±1.40
TBIL (μmol/L)	3.37±0.13	3.38±0.17	3.67±0.29
ALP (×10² U/L)	11.43± 0-50	11.13± 0.53	11.26±0. 24
ALT (U/L)	11.25±0.93^{b}	15.17±2.18^{ab}	19.94±2.19^{a}
AST (U/L)	63.51±3.74	62.98±3.67	64.96±2.64

^{a,b}Means within a row different letters differ ($P < 0.05$). †Data are means of 6 replicates, with 2 samples per replicate. Values are mean ± SE. ‡BUN, blood urea nitrogen; GLU, glucose; TBIL, total bilirubin; ALP, alkaline phosphatase; ALT, alanine aminotransferase; AST, aspartate aminotransferase.

Serum biochemical indicators in broilers

Serum ALP enzyme activity in T2 group was decreased ($P < 0.05$) as compared with the CON group at 21d of age of broilers (Table IV). Serum BUN content and ALT enzyme activity in T2 group were higher ($P < 0.05$) than that of the CON group at 42d of age in broilers.

Serum protein in broilers

Serum TP, ALB and GLB levels in broilers were presented in Table V. Serum GLB content in T2 group was lower ($P < 0.05$) than that of the CON group at 21d of age in broilers. Serum TP content in T2 group was decreased ($P < 0.05$) as compared with the CON group at 42 d of age in broilers.

Table V.- Effects of natamycin on serum TP, ALB and GLB content in broilers†.

Item‡	CON	T1	T2
21 d			
TP (g/L)	25.35±1.30	24.90±1.46	22.95±1.49
ALB (g/L)	17.50±0.75	17.12±0.97	16.60±0.88
GLB (g/L)	8.22±0.51^{a}	7.78±0.43^{a}	6.37±0.52^{b}
42 d			
TP (g/L)	28.24±0.21^{a}	28.48±0.36^{a}	27.37±0.24^{b}
ALB (g/L)	17.90±1.05	18.08±0.51	17.68±0.31
GLB (g/L)	10.34±0.29	10.48±0.30	9.77±0.17

^{a,b}Means within a row different letters differ ($P < 0.05$). †Data are means of 6 replicates, with 2 samples per replicate. Values are mean ± SE.‡TP, total protein; ALB, albumin; GLB, globulin.

Table VI.- Effects of natamycin on serum antioxidant capacities in broilers†.

Item‡	CON	T1	T2
21 d			
T-AOC (U/mL)	12.49±0.31^{b}	14.48±0.85^{a}	13.66±0.58^{ab}
T-SOD (U/mL)	82.40±10.12	85.32±5.10	84.76±7.99
GSH-Px (U/mL)	324.19±4.00	361.14±11.22	343.77±21.5
MDA (nmol/mL)	2.03±0.12^{a}	1.62±0.04^{b}	1.85±0.10^{ab}
42 d			
T-AOC (U/mL)	12.91±0.62	13.20±0.69	13.13±0.33
T-SOD (U/mL)	80.42±3.53	82.24±8.05	79.70±7.21
GSH-Px (U/mL)	334.6±13.32^{b}	379.43±18.06^{a}	332.95±7.52^{b}
MDA (nmol/mL)	2.01±0.13	1.85±0.23	2.00±0.09

^{a,b}Means within a row different letters differ ($P < 0.05$). †Data are means of 6 replicates, with 2 samples per replicate. Values are mean ± SE. ‡T-AOC, total antioxidant capacity; T-SOD, total superoxide dismutase; GSH-Px, glutathione peroxidase; MDA, malondialdehyde.

Serum antioxidant enzymes in broilers

In comparison with the CON group, serum T-AOC was higher ($P < 0.05$) and MDA content was lower ($P < 0.05$) in T1 group at 21 d of age in broilers (Table VI). The highest ($P < 0.05$) serum GSH-Px enzyme activity was found in T1 group as compared with other two groups at 42 d of age of broilers.

Table VII.- Effects of natamycin on hepatic antioxidant capacity of broilers†.

Item‡	CON	T1	T2
T-AOC (U/mg·prot)	1.63±0.03	1.66±0.18	1.67±0.21
T-SOD (U/mg·prot)	208.9±6.08	222.0±5.28	216.02±13.47
GSH-Px (U/mg·prot)	11.14±0.44	12.56±0.53	12.05±0.42
MDA (nmol/mg·prot)	0.49±0.01[a]	0.44±0.01[b]	0.46±0.02[ab]

[a,b]Means within a row different letters differ ($P < 0.05$). †Data are means of 6 replicates, with 2 samples per replicate. Values are mean ± SE. ‡T-AOC, total antioxidant capacity; T-SOD, total superoxide dismutase; GSH-Px, glutathione peroxidase; MDA, malondialdehyde.

Table VIII.- Effects of natamycin on liver antioxidant genes of broilers†.

Item‡	CON	T1	T2
Nrf2	1.00±0.34	1.37±0.43	1.09±0.03
SOD1	1.00±0.04	1.29±0.12	1.01±0.12
SOD2	1.00±0.07	1.02±0.09	0.98±0.06
GPx1	1.00±0.08	1.23±0.07	1.11±0.10
CAT	1.00±0.10	1.09±0.10	0.94±0.11

†Data are means of 6 replicates, with 2 samples per replicate. Values are mean ± SE. ‡The mRNA level of each gene in the control group was set to be 1.

Hepatic antioxidant enzyme activities in broilers

The results of hepatic antioxidant enzyme activities and lipid peroxidation level at 42d of age in broilers are shown in Table VII. The results found that the hepatic MDA content in T1 group was decreased ($P < 0.05$) as compared with the CON group in broilers.

Hepatic antioxidant genes in broilers

There was no significant difference found ($P > 0.05$) in hepatic antioxidant mRNA expression of among all treatments in broilers (Table VIII).

DISCUSSION

Natamycin, an effective food preservative, is widely used in food industry against fungi (Rasgele and Kaymak, 2013; Arima *et al*., 2014). Although natamycin would not destroy mycotoxins already present in raw feed ingredients, it would limit further growth of mold after mixing in feed (Swick, 1996). Natamycin has been used as a preservative in feed industry recently. Qi *et al*. (1998) reported that the application of natamycin in the poultry feed industry could effectively control the disease caused by *Aspergillus*. In the present study, the result indicated that natamycin had no effect on growth performance in broilers during the whole experimental period. The result was similar to the findings of Struyk *et al*. (1958) who found that the oral administration of natamycin at dose levels of 50-70 mg/kg BW per day for 5-10wk had no effects on the growth in rats.

The liver has a wide range of functions, including detoxification, protein synthesis, and production of biochemical necessary for digestion. Liver damage is a major obstacle in the development of new drugs and is also a major reason for withdrawal of drugs from the market (Cullen and Miller, 2006). Conventional analysis of serum biochemical parameters to identify organ system effects is the “corner stone” in testing the effects of new drugs (Ramaiah, 2007). Serum biochemical parameters which referred to several enzymes could provide important and useful information in assessing liver damage (Che *et al*., 2011). Hepatic insufficiency could result in a low serum BUN content and a high plasma ammonia, since the urea cycle in the liver is the major pathway for conversion of intestinal derived ammonia to urea nitrogen (Ramaiah, 2007). In the present study, broilers fed diets supplemented with 50 mg/kg natamycin had higher levels of serum BUN at 42 d of age. This indicated that 50 mg/kg doses of natamycin may weaken hepatic function, therefore, leading to accumulation of serum BUN in broilers at 42d of age.

The alkaline phosphatase (ALP), as a key regulatory enzyme *in vivo*, could accelerate metabolism and promote animal growth by increasing the ALP activity in serum. Phosphatases including ALP play a key role in metabolism and biosynthesis of energetic macromolecules for a variety of vital functions (Zhou *et al*., 2012). In this study, serum ALP enzyme activity of broilers was decreased by dietary natamycin supplementation at a dose level of 50 mg/kg as compared with the CON group at 21d in broilers. The result indicated that 50 mg/kg of natamycin may have negative effects on the liver in broilers. Measurement of serum ALT enzyme activity provides a sensitive and specific indicator of hepatic function or injury, as this enzyme is present in large quantities in hepatocytes (Abbès *et al*., 2006) and it increases in serum when cellular degeneration or destruction occurs in the liver (El-Demerdash, 2004). The higher serum ALT enzyme activity in broilers supplemented with natamycin at level of 50 mg/kg of diets may indicate that 50 mg/kg of natamycin could cause some damage in liver cells. In addition, the serum GLB and TP levels in broilers were decreased by dietary supplementation with 50 mg/kg of natamycin as compared with the CON group. These results indicated that the doses of natamycin may have an adverse effect on protein balance.

Antioxidant system in animal body consists of antioxidant enzymes which includes glutathione peroxidase enzyme (GSH-Px) and superoxide dismutase (SOD). GSH-Px, is an important antioxidant enzyme in body that catalyzes reduced glutathione to clear hydrogen peroxide and reduce the generation of lipid peroxides, as a result protecting the structure and functions of cell membrane, while, SOD directly participates in anti-oxidation process (Ahmad *et al*., 2012). T-AOC has been measured to assess the antioxidant and nutritional status of the living body (Cao and Prior, 1998). MDA is the end product of lipid peroxidation, which is associated with many physiological disorders and diseases in the body. Many studies have shown that lipid peroxidation induces disturbance and alteration of biological membranes (Niki, 2010). Antioxidant capacity for inhibition of lipid peroxidation can be assessed by measuring the extent of suppression of lipid peroxidation and antioxidant enzyme activities. In the present study, diets supplemented with 10 mg/kg natamycin had higher level of antioxidant activity in serum, and lower MDA content in serum and liver of broilers. These results may be due to natamycin could effectively inhibit mold in diets to prevent mycotoxin production (Lantano *et al*., 2014) and lipid peroxidation, thereby enhancing the antioxidant capacity in the body as some molds could produce mycotoxins such as aflatoxin B_1, leading to lipid peroxidation and high MDA content in liver cells (Shen *et al*., 1994). However, there is a little information available about the effects of natamycin on antioxidant capacity in broilers at present. Further studies are required to know the exact mode of action of natamycin to provide a more scientific basis for the rational use of natamycin in poultry diets.

In the present study, diets supplemented with 10 mg/kg natamycin had a positive influence on liver protection in broiler chickens. Supplementation of 10 mg/kg natamycin in poultry diets may improve serum and hepatic antioxidant enzyme activities in broilers. However, more investigations with regard to the usage of natamycin in broilers should be carried out.

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Statement of conflict of interest

Authors have declared no conflict of interest.

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