EFFECTS OF CAPSAICIN SUPPLEMENTATION ON PRODUCTIVE AND PHYSIOLOGICAL PERFORMANCE OF PEKIN DUCKS DURING SUMMER SEASON

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SUMMARY

The aim of this study was to evaluate the effect of using graded levels of capsaicin on growth performance, nutrients digestibility coefficients, serum metabolites, oxidative responses and intestinal digestive enzymes activity of Pekin ducks. One hundred and twenty 14d old Pekin ducks were randomly divided into four groups of 30 ducks. The first group was fed on the basal diet (control), while groups 2, 3 and 4 were given the basal diet supplemented with 50, 100 and 150 ppm capsaicin, respectively. The results showed significant improvement in body weight and feed conversion of ducks, particularly with the high level (150ppm) followed by those of the mid one (100pm). Moreover, supplemental capsaicin with different levels enhanced digestibility coefficient values especially with ether extract (EE) and nitrogen free extract (NFE) in Pekin ducks. The serum level of total proteins, globulin, high density lipoprotein (HDL), triiodothyronine (T3), thyroxin (T4) and antioxidant enzymes was significantly increased for ducks fed on diets contained either 100 or 150ppm capsaicin. But, the concentrations of total lipid, cholesterol, triglycerides, low density lipoprotein (LDL), glucose and malondialdehyde (MDA), which is the primary stable by-product of lipid peroxidation, were reduced. On the other hand, the albumin level didn't significantly affected by dietary capsaicin supplementation. A significant increase in the activities of amylase, lipase and trypsin enzymes was found throughout the small intestine portions with supplemental capsaicin. It is concluded that, capsaicin supplementation with 100ppm up to 150ppm was sufficient to enhance the growth performance traits, nutrients digestibility, thyroid and antioxidant system in growing Pekin ducks. In addition to, using these natural feed additives had clear favorable effect on enzymatic and microbiological profile in small intestine, without adverse effects on liver activity.

Keywords: *Capsaicin, Pekin ducks, growth, serum constituents, antioxidant enzymes, digestive Enzyme*

INTRODUCTION

High temperature imposes severe stress on birds and leads to important economic losses in the poultry industry. Although birds perform well within a relatively wide range of temperatures, between 10 and 27°C (Daghir, 2009), temperatures above 30°C may cause stress in adult hens (Daghir, 1995) and broiler chickens (Geraert *et al*., 1996). Several feed compounds are related to stress levels in animals and some may be used for preventing heat effect. Between them are some antioxidants like capsaicin (Lee *et al*., 2003), because the oxidative injury induced by high ambient temperatures has been demonstrated in several studies (Mujahid *et al*., 2006), and the oxidative stress should be considered as part of the stress response of chickens to heat exposure.

Hot red pepper is one of the most important herbs, which is widely used in human feed all over the world; Capsinoids are widely present at low levels in chilli pepper fruit, it includes capsaicin, dihydrocapsaicin and it has a very favorable safety profile (Vicente *et al*. 2007). Capsaicin, a homovanillic acid derivative (8-methyl-N-vanillyl-6-moneamide) is an irritant and vasoactive compound from chilli (Capsicum annum) powder (Vicente *et al*. 2007). Dried pods of Capsicum annum or chilli contain 1.8% capsaicin (Pruthi 2003).

Capsaicin has been reported to have effects as alkaloid component can induce body heat as well as increase energy expenditure, anti-inflammatory (Choi *et al*., 2011) and antioxidant properties (Henning *et*

al., 2011). It also decrease in adipose tissue mass has a role to play in weight management. In addition, capsaicin affects various physiological functions which include intestinal peristalsis (Hellgren *et al*., 2000), gastroprotection (Szoscanyi and Bartho, 2001), temperature regulation (Nomoto *et al*., 2004), modulation of the energy metabolism (Kawada *et al*., 1986), immune status (Yu *et al*., 1998) and blood neuthrophils (Zhukova and Makarova, 2002). Capsaicin has also been found to exert protective effect against Salmonela enteritidis infection in laying hens (Vicente *et al*., 2007). The presence of the capsaicin in these species has long been associated with strong analgesic properties (Cordell *et al*., 1993), alterations in the pH of gastrointestinal tract epithelial cells, prevention of microbial infection (Tellez *et al*., 1993).

The main purpose of this study was carried out to evaluate the effect of different dietary levels of capsaicin on the performance and oxidative status of ducks.

MATERIALS AND METHODS

The experimental study was carried out at Poultry Experimental Unit, Agricultural Experiment and Research Station at Shalakan, Faculty of Agriculture, Ain Shams University, Egypt.

Birds, Diet and Experimental Design

One hundred and twenty, 14-day old of unsexed Pekin ducks were used from June to July in 2016 and were weighed and equally distributed among four groups, each group contained three replicates; each replicate consisted of 10 birds. The first group was fed on the basal diet (control), while groups 2, 3 and 4 were given the basal diet supplemented with 50, 100 and 150 ppm capsaicin, respectively. Capsaicin purchased from SIGMA-ALDRICH Chemical Co., India was mixed in the powdered basal diet at a concentration of 50, 100 and 150 p.p.m. (w/w). These experimental diets were prepared on a weekly basis and stored in a cold room (<4°C) until use. During the experimental period (14-56 day of age), the birds were reared on floor in open-sided house and were kept under the same managerial, hygienic and environmental conditions till the age of 56 day. Feed and water were provided for *ad libitum* consumption throughout the experimental period. Birds were maintained on a light cycle of 16L: 8D. The grower diet (Table 1) was formulated to meet all requirements recommended by NRC (1994).

Table (1). Composition and calculated analysis of basal diet.

Ingredient %	Grower (14-56)
Yellow corn	58.50
Soybean meal (44%)	35.50
Corn gluten meal (60%)	2.00
Di-calcium phosphate	1.90
Lime stone	1.20
Sodium chloride	0.30
Vit. and min. premix*	0.30
DL- methionine	0.20
L- lysine HCl	0.10
Total	100
Crude protein (CP)	21.75
Crude fibber (CF)	3.74
Ether extract (EE)	1.90
ASH	6.17
Calculated values:	
Metabolizable energy (Kcal/kg)	2825.80
Crude protein (CP)	22.04
Calcium %	1.05
Available phosphorus %	0.74
Lysine %	1.39
Methionine + Cysteine %	0.94

** Each3 kg Vitamins and minerals contain: Vit. A120000IU, Vit. D3 22000 IU, Vit.E100 mg, Vit.K3 20mg, Vit. B1 10 mg, Vit. B2 50mg, Vit. B6 15 mg, Vit.B12 100 µg, Pantothenic acide 100mg, Niacin 300mg, Folicacid 10 mg, Biotin500µg, iron300mg, Manganese 600 mg, Choline chloride 500 mg, Iodine 10 mg, Copper 100 mg, Seleneium 1 mg, Zinc 500 mg and 1200 mg Anti-oxidant*

The body weight gains of birds were measured individually and feed consumption and feed conversion efficiency (g feed: g gain) were measured weekly.

At the end of the experimental period three birds from each group were housed in separate metabolic cages for 5 days. After a 3 days preliminary period, feed intake and excreta were measured and collected during 5 days. The proximate analyses of feed and dried excreta were determined according to AOAC (1995).

Nine blood samples per group (three/ replicate) were obtained from left wing vein at 56 day of birds' age for measurement of blood parameters. Five ml blood was taken from each bird in a sterile plastic syringe. The blood samples were collected in clean centrifuge tubes and left at room temperature for 20 minutes to clot. They were centrifuged at 3000 rpm for 15 min for separation of blood serum.

Quantitative determination of blood serum was included the following: total proteins, albumin, globulins (determined by subtraction the value of albumin for the sample from its corresponding value for total proteins), glucose, total lipids, total cholesterol, Low Density Lipoprotein (LDL-cholesterol), High Density Lipoprotein (HDL~ cholesterol) and liver enzymatic activity (AST and ALT) concentrations by using Atomic Absorption spectrophotometer and suitable commercial diagnostic kits following the same steps as described by manufactures (Bio-Diagnostics company, Egypt). Concentration of triiodothyronine (T3) and thyroxin (T4) were determined using commercial enzyme immunoassay test kit purchased from Taytec Incorporation (7278 Aldercrest Dr., Mississauga, ON, L5N 7N8, Canada). Serum Insulin hormones using kits supplied by Daimmond Diagnostic (Giza, Egypt). Serum Malondialdehyde (MDA) was measured by the method described by Ohkawa *et al*. (1979). Superoxide dismutase (SOD) and catalase (CAT) were measured in erythrocytes calorimetrically according to methods of Nishikimi *et al*. (1972) and Aebi, (1984), respectively.

Intestine was removed and the digest contents of this intestinal segment (1 g) were collected and homogenized with 10 ml phosphate buffer solution. The digest specimens were sent packed on ice to the laboratory (Microbiological Laboratory, MERCIN, Faculty of Agriculture, Ain Shams University) for enumeration of total bacteria, E. coli and Lactobacilli spp. The contents of duodenum, jejunum and ileum were collected, form the slaughtered bird, weighed and kept in equal volumes of sterilized physiological saline. They were then individually centrifuged and the supernatant fluids were decanted and used for determination of some digestive enzymes activity (amylase, lipase and trypsin) as described by Nitsan *et al*. (1991).

Data were statistically analyzed according to SAS (2001) computer program using the following fixed model: $Y_{ij}=\mu + T_i + e_{ij}$

Where: Y_{ij} = the observation; μ = overall mean; T_i = effect of treatments; eij= random error component assumed to be normally distributed. Duncan's multiple range tests was performed (Duncan, 1955) to detect significant differences among means.

RESULTS AND DISCUSSION

Productive performance

The effects of dietary capsaicin supplementation at different levels on LBW, BWG and FCR of Pekin ducks are listed in Table 2. Results showed significant improvement in all studied productive performance data as the level of dietary capsaicin level increased. However, the group of 100 ppm capsaicin didn't significantly differ from those of 50 ppm.

The effect of feeding graded level of capsaicin indicated that supplemented birds with capsaicin had no significant effect on feed consumption in all levels (Table, 3). The absence of significantly affects of this additive on feed intake may probably due to the birds requires of long time to adapted to this additive. Body weight gain and feed conversion ratio in the present study, showed a significant improvement of birds that fed on the diets supplemented with capsaicin at various levels compared with that control group. Our results were compatible also with, El Tazi (2014) who reported that inclusion of capsaicin in the diet at levels of 0.5, 0.75 and 1% improvement significantly body weight gain and feed conversion ratio of broiler chicks. The better body weight gain and feed conversion ratio may be due to the antimicrobial properties of capsaicin the activity ingredients in this supplement which possess which can lead to decrease the harmful microbes in digestive system and increased the mucosa and sub-mucosa thickness of small intestine and absorption surface of duodenum an alliums of broiler (Chiej, 1984).

Meanwhile, it might be to the active compound (capsaicin) that improves feed conversion which is reflected on body weight improvement (Al- Kassie *et al*. 2012) Also, these results were agreement with (El Husseiny *et al*., 2002) who stated that the levels of 1, 1.5 and 2% of bird of the diets improved significantly body weight gain and feed conversion ratio On the other hand, El Husseiny *et al*., (2002) reported that feed intake of broiler decreased as the level of hot red pepper increased to 2%. However, the results of the present study showed that, capsaicin at different levels of inclusion, performed similar to antibiotic growth promoter on body weight gain, feed intake and feed conversion ratio of Pekin ducks.

Table (2). Productive performance of Pekin ducks fed supplemental capsaicin.

Item	Capsaicin levels (ppm)			
	0	50	100	150
Live Body weight				
2wk	656±11.95	652.12±9.28	651.15±15.37	650.50±13.58
4 wk	1250.53^{d}±9.08	1286.36^{c}±13.62	1353.92^{b}±5.13	1393.93^{a}±8.68
6 wk	1623.50^{c}±14.71	1731.67^{b}±13.30	1755.00^{b}±15.55	1905.00^{a}±17.34
8 wk	2091.67^{d}±23.73	2227.42^{c}±15.81	2297.05^{b}±17.34	2370.46^{a}±23.45
Body weigh gain				
2-4 wk	594.53^{b}±17.04	634.24^{b}±15.64	702.77^{a}±15.66	743.43^{a}±17.73
4-6 wk	372.97^{c}±16.86	445.31^{b}±17.91	401.08^{bc}±16.33	511.07^{a}±17.46
6-8 wk	468.17^{b}±23.95	495.75^{b}±22.01	542.05^{a}±22.56	465.46^{b}±20.88
2-8 wk	1435.67^{c}±29.55	$1575.\ 30^{b}$±20.59	1645.90^{ab}±28.64	1719.96^{a}±26.66

a, b, c and d: Means within a row with different superscripts are significantly different at (P≤ 0.05).

Table (3). Feed intake and feed conversion ratio of Pekin ducks fed supplemental capsaicin.

Item	Capsaicin levels (ppm)			
	0	50	100	150
Feed intake				
2wk	1248.20±9.20	1247.20 ±8.49	1225.42±9.18	1218.78±8.83
4 wk	1895±19.71	1885±22.10	1854.17±15.64	1850±26.82
6 wk	3805.83±29.06	3888.28±33.24	3954.17±26.64	4035.83±26.82
8 wk	6949.03±29.86	6992.12±25.20	7029.58±29.13	7048.63±22.50
Feed conversion ratio				
2 wk	2.12a±0.08	1.93b±0.04	1.75c±0.04	1.69c±0.05
4 wk	5.22a±0.30	4.31bc±0.20	4.80ab±0.28	3.68c±0.18
6 wk	8.36ab±0.42	8.03ab±0.39	7.44b±0.32	8.87a±0.42
8 wk	4.86a±0.10	4.44b±0.06	4. 28bc±0.08	4.10c±0.06

a, b and c: Means within a row with different superscripts are significantly different at (P≤ 0.05).

Nutrient digestibility

The effect of treatments on the nutrients digestibility coefficients of dry matter (DM), crude protein (CP), crude fiber (CF), ether extract (EE) and nitrogen free extract (NFE) are summarized in Table 4. Nutrient digestibility coefficients of DM, EE and NFE were significantly (P<0.05) increased by capsaicin supplementation. Several studies (Garcia et al. 2007) have shown that plant extracts such as capsaicin improved the digestibility values of diets in broilers. They attributed that to the addition of capsaicin to the diet may affected energy metabolism by activating the sympathetic nervous system in animals. However the mechanisms of improvement of digestibility coefficient values of EE by capsaicin may be through increasing the secreation of lipase and secondary bile acids (Platel and Srinivasan, 2004). On the other hand, the improvement of digestibility coefficient values of EE and NFE may be attributed to the potential beneficial effect of these additives capsaicin on gastrointestinal tract micro-organisms and metabolites which be reflected on improving the digestibility of feed nutrients and conversions.

However, no effect of supplementation was detected for CP and CF digestibility (Table 4). Phenolic compounds (capsaicin) of plant extracts did not affect the apparent CP digestibility of diets, whereas, polyphenol compounds known to combine with proteins and consequently block the lysine, tryptophan, and cysteine residues. Protein bound in this form decreased the digestibility and biological value of protein (Rawel *et al*., 2002).

Table (4). Nutrients digestibility coefficients and intestinal bacterial count of Pekin ducks fed supplemental capsaicin.

Item	Capsaicin levels (ppm)			
	0	50	100	150
DM%	76.18^{b}±0.07	76.22^{b}±0.11	78.12^{ab}±0.32	79.64^{a}±0.30
CP%	72.74±3.25	72.88±2.32	72.01±3.04	72.97±3.69
CF%	18.44±1.18	18.15±1.23	18.63±1.96	18.14±1.35
EE%	75.85^{b}±0.22	76.11^{b}±0.22	78.34^{a}±0.29	79.25^{a}±0.28
NFE%	75.50^{c}±0.26	76.56^{bc}±0.24	78.16^{ab}±0.32	79.15^{a}±0.26
T. count (log CFU/ g)	6.44^{a}±0.11	6.13^{ab}±0.07	5.85^{b}±0.18	5.91^{b}±0.12
Coliform count (log CFU/ g)	6.26^{a}±0.04	6.23^{ab}±0.09	6.20^{ab}±0.12	5.95^{b}±0.11
Lactic acid count (log CFU/ g)	3.06^{b}±0.03	2.92^{b}±0.13	3.09^{b}±0.08	3.72^{a}±0.22

a, b and c: Means within a row with different superscripts are significantly different at ($p \leq 0.05$).

Microbial determination

Data presented in Table 4, show the effect of different dietary treatments on total viable bacteria, coliform and lactic acid bactreia counts in small intestine (mean log 10 CFU/ g). Lowest value of mean log CFU/ g of total bacteria were recorded for Pekin ducks fed capsaicin compared to those fed the control diet especially with the mid and high dosages. In addition, lowest value of mean log CFU/ g of coliform bacteria were recorded for ducks fed highest capsaicin level (150ppm) compared to those fed other diets. Moreover, feeding (highest capsaicin level (150ppm)) diet showed positive effect on lactic acid bacteria counts. These results are in agreement with those obtained by Jamroz *et al*. (2003) determined that plant extract (carvacrol, cinnamaldehyde and capsaicin) reduced the total E. coli and can control Clostridium perfringens colonization in the intestine and feces of broiler chickens. Antibacterial, anticoccidial, antifungal and antioxidant effects of capsaicin (Chevallier 1996), and which has effects on the resistance to *Salmonella enteritidis* infection by altering pH and histological changes (McElroy *et al*., 1994). In this respect, red pepper leads to increase of acid secretion (Ononiwu *et al*., 2002). Increased gastric mucus production has been suggested as one mechanism by which capsaicin and chilli exert their gastroprotective effect, and reduction in mucosal mucus depletion which has been found to act as secondary protective effect of capsaicin and chillis (Holzer and Sametz, 1986).

In general, the development of the gastrointestinal tract, especially that of the intestinal mucosa, is related to the stimulation of the process of cell mitosis and the modulation of the enteric microbial flora, where the addition of capsaicin reduces the microbial population, diminishing the competition for nutrients between the bacteria and the host, along with the reduction of direct injuries to the intestinal mucosa (Barreto *et al.*, 2008).

Another explanation, it has been reported that, the antibacterial activity of capsaicin was suggested to be associated with the presence of phenolic constituents (Shan *et al*., 2007), even though the exact antimicrobial mechanism of phenolic compounds is not clear. The ability of phenolic compounds to alter microbial cell permeability, thereby permitting the loss of macromolecules from the cell interior, could help explain some of the antimicrobial activity Bajpai *et al*., 2008), or it might be that phenolic compounds interfere with membrane function and interact with membrane proteins, causing deformation in structure and functionality (Bajpai *et al*., 2008).

Digestive Enzyme Activities

Effect of feeding pekin ducks on diets contained various capsaicin dosages on the digestive enzyme activities in different segments of small intestine (duodenum, jejunum and ileum) are presented in Table (5). It is clearly observable that, the activity of amylase enzyme in the duodenum was significantly lower in the control group than the groups of capsaicin. Similar trend was achieved in the jejunum portion, although the absence of significant differences between the control chicks and those of 50ppm capsaicin. The activity values within the ileum were only significant for pekin ducks received the highest capsaicin level (150ppm). Concerning lipase enzyme the current findings indicated that, its activity was affected with the addition of capsaicin. Where, the statistical significant differences were noted only between the group control group and the highest capsaicin level (150ppm) in both the jejunum and ileum. This may be associated with the action of capsaicin in oxidation of fatty acids as previously mentioned herein. Results of trypsin enzyme activity showed that, it was elevated significantly with supplemental capsaicin with

150ppm compared with the control treatment within the first small intestinal portion (duodenum). Similar trend, however, non significant was obtained in the second and third portions (jejunum and ileum).

The presence of extracts containing capsaicin (red pepper) stimulated production and secretion of salivary amylase and pancreatic and intestinal enzymes in birds (Lee *et al*. 2004). Platel and Srinivasan (2000), when they affirmed that capsaicin has showed to be efficient in stimulating salivation in pigs (amylase production) and by (Brugalli, 2003), who reported that there is increase in the secretion of pancreatic and intestinal enzymes, promoting, thus, reduction in the intestinal viscosity and improving the digestive process.

In general, the results showed that there was a tendency toward increasing the activity of all tested digestive enzymes (amylase, lipase and trypsin) throughout the small intestine portions with supplemental capsaicin. Thus, the dietary capsaicin, which either enhanced the activity of digestive enzymes or caused a higher secretion of bile acids, also reduced the food transit time at the same level of consumption. This reduction in food transit time could probably be attributed to acceleration in the overall digestive process as a result of increased availability of digestive enzymes and of bile acids that facilitate fat digestion (Platel and Srinivasan, 2004). These results may interpret, to a great extent, the current growth performance data.

Table (5). Digestive enzyme activities (Unit/dl) throughout the small intestine of Pekin ducks fed supplemental capsaicin

Item	Capsaicin levels (ppm)			
	0	50	100	150
Enzyme type (U/dl) in Duodenum				
Amylase	$1.97^{c}\pm0.04$	$1.96^{c}\pm0.07$	$2.28^{b}\pm0.11$	$2.68^{a}\pm0.06$
Lipase	$8.97^{c}\pm0.19$	$8.70^{c}\pm0.19$	$9.98^{b}\pm0.27$	$10.80^{a}\pm0.15$
Trypsin	$24.54^{b}\pm0.85$	$26.73^{ab}\pm0.32$	$27.78^{ab}\pm0.68$	$31.76^{a}\pm3.33$
Enzyme type (U/dl) in Jejunum				
Amylase	$2.01^{c}\pm0.06$	$2.08^{bc}\pm0.10$	$2.32^{b}\pm0.10$	$2.64^{a}\pm0.07$
Lipase	$8.99^{c}\pm0.19$	$8.62^{c}\pm0.19$	$9.98^{b}\pm0.22$	$10.69^{a}\pm0.20$
Trypsin	24.43±0.76	24.17±0.19	24.90±1.39	24.43±1.70
Enzyme type (U/dl) in Ileum				
Amylase	$2.13^{b}\pm0.11$	$2.01^{b}\pm0.13$	$2.23^{b}\pm0.07$	$2.66^{a}\pm0.06$
Lipase	$8.92^{c}\pm0.16$	$8.82^{c}\pm0.17$	$9.73^{b}\pm0.35$	$10.58^{a}\pm0.17$
Trypsin	24.43±0.76	24.95±1.40	24.12±1.48	24.87±1.51

a, b and c: Means within a row with different superscripts are significantly different at ($p \leq 0.05$).

Serum Constituents

Data presented in Table 6, that dietary addition of capsaicin insignificantly increased serum total proteins especially with the mid and high dosages when compared with the unsupplemented control ones.

Results in Table 6 illustrated that; supplemental capsaicin could effectively reduce the serum concentrations of total lipid, cholesterol, triglycerides and LDL. Contrary, the level of serum HDL was raised due to capsaicin addition. Moreover, the effect was markedly observed with the high dosage (150ppm) followed by the mid one (100ppm). These results were agreement with Kang *et al*., (2007) published that capsaicin suppressed the oxidation of LDL, lowered LDL, and inhibited the transformation of cholesterol to oxidized products. A Capsaicin treatment was found to decrease LDL and TG, and increase HDL with no noticeable affect on serum total cholesterol. The reduction in serum cholesterol in diet supplementing by capsaicin could be attributed to the active capsaicin which inhibit the activity 3-hydroxyl-3-methyl glutaryle-co-A reeducate will lower serum cholesterol in poultry up to 2% (Srinivasan and Sambaiah, 1991), also they reported that capsaicin could stimulate the conversion of cholesterol to bile acids, an important path way of excretion of cholesterol. On the other hand, these results indicate that extensive consumption of capsaicin reduce adiposity, a phenomenon which can be explained partly by the enhancing effects of capsaicin on energy and lipid metabolism via catecholamine secretion from the adrenal medulla (Kawada *et al*., 1988). Since an increase in sympathetic nervous system (SNS) activity affects food intake behaviour (Raben *et al.*, 1996), they hypothesized that the usage of capsaicin to the diet can decrease food intake and that this is associated with an increase in SNS activity and reflected that on energy and lipid metabolism.

Table (6). Serum biochemical constituents and liver functions of Pekin ducks fed supplemental capsaicin

Item	Capsaicin levels (ppm)			
	0	50	100	150
Total protein (g/dL)	4.96±0.17	5.08±0.16	5.34±0.17	5.45±0.12
Total lipid (mg/dL)	963.38^{a}±13.76	904.17^{b}±12.62	855.59^{c}±13.01	795.54^{d}±13.67
Cholesterol (mg/dL)	311.38^{a}±2.97	249.61^{b}±2.38	195.59^{c}±1.58	195.55^{c}±1.67
TG (mg/dL)	212.06^{a}±2.76	206.06^{ab}±3.15	201.82^{b}±1.89	201.57^{b}±1.32
HDL (mg/dL)	26.13^{b}±1.27	36.85^{a}±1.86	35.96^{a}±1.08	38.70^{a}±1.69
LDL (mg/dL)	172.74^{a}±0.25	162.55^{b}±3.47	154.79^{c}±1.62	151.19^{c}±2.68
AST (U/I)	111.86±1.59	106.42±2.44	103.50±1.52	105.61±2.63
ALT (U/I)	34.31±2.21	34.40±2.19	34.58±2.37	35.60±1.71
Glucose (mg/dL)	178.70^{a}±3.01	175.52^{a}±1.65	157.28^{b}±1.31	151.55^{c}±0.46

a, b and c: Means within a row with different superscripts are significantly different at ($p \leq 0.05$).

It was clearly evident from (Table, 6) that dietary addition of capsaicin significantly decreased serum glucose, especially with the mid and high dosages. Whereas, ducks whose diet was contained the low capsaicin level had slightly higher serum glucose when compared with the unsupplemented control ones. In a study by Kang *et al*. (2010) dietary capsaicin decreased glucose levels in the plasma. Capsaicin which is the main component of chilli inhibits the intestinal absorption of glucose and this justifies the hypoglycaemic effect of chilli as pointed by Al- Kassie *et al*. (2011). However, the lower circulatory glucose concentration in the capsaicin supplemented birds was perhaps indicative of an increased turnover rate and utilization of glucose at the tissue level.

In general, the increase in glucose concentration in control group is directly responsive to an increase in glucocorticoids (Borges *et al*., 2007), which can result from various stressors including heat stress. Glucocorticoids have primary effects on metabolism, stimulating gluconeogenesis from muscle tissue proteins. Rashidi *et al*. (2010) reported that high environmental temperature increased levels of plasma glucose and cholesterol and reduced protein level. Comparable results were obtained in this study where concentration of serum glucose and cholesterol increased in heat stressed control. The increase in blood lipids under heat stress was explained by Rashidi *et al*. (2010) that high temperature reduced feed intake and broilers compensate their need to energy by lipolysis of body lipid that it causes increasing the blood cholesterol and triglycerides. At the meantime, a significant decrease in these traits was recorded in the groups treated with capsaicin levels, indicating a good ameliorating effect with the used capsaicin.

As shown in Table 6, the activities of serum AST and ALT, as an indication of liver function, didn't significantly differ among all treatments due to dietary capsaicin inclusion indicated that it had no deleterious effect on liver cells. This result was supported by the finding of the (Saha and Das, 2003) who reported that, capsaicin have high level of antioxidant, this have modulating role on physiological function and biotransformation reaction involved in detoxification process there by providing protection from cytotoxic, genotoxic and metabolic effect of environment toxicant so inclusion of capsaicin caused stabilized cell membrane and protect the liver deleterious agent and free radicals mediated toxic damages to the liver cells which is desirable (Aderemi, *et al*., 2013). At the same time, El Husseiny *et al*. (2002) who found that, the addition of hot red pepper at level of 1, 1.5 and 2% in broiler diet had no any significant cumulative toxicity at doses administrated.

Thyroid Gland Activity and Insulin Hormone

As shown in Table 7, thyroid hormones (T_3 and T_4) as well as their calculated ratios were significantly increased in a linear manner due to capsaicin supplementation especially with highest dosage. In addition, it is noticeable the lack of statistical significance between control, the low (50ppm) and the mid (100ppm) level. The excitation of the peripheral nervous system caused by capsaicinoids may lead to an increase in thyroliberin (TRH) secretion as a result of the activation of α-adrenergetic receptors in the paraventricular nucleus (PVN). This, in turn, leads to an increase in the synthesis and secretion of TSH responsible for stimulating the release of total T4 by the thyroid gland (Shirpour *et al*., 2003).

As it was apparent from our results that treatment of ducks with capsaicin afforded a significant increase in serum thyroid hormones, these hormones influence all major metabolic pathways. Their most obvious and well known action is an increase in basal energy expenditure obtained acting on protein, carbohydrates and lipid metabolism. Thyroid hormones affect synthesis, mobilization and degradation of

lipids, although degradation is influenced more than synthesis (Pucci *et al.*, 2000). They favor lipolysis in adipose tissue resulting in a decrease in plasma cholesterol content and they may have an indirect effect on lipogenesis (Eshkhatkhah *et al*., 2010).

Table (7). Thyroid hormone activities, Insulin hormone, lipid peroxidase and antioxidant enzymes levels Pekin ducks fed supplemental capsaicin

Item	Capsaicin levels (ppm)			
	0	50	100	150
T3 (ng/ml)	2.95^{b}±0.13	2.60^{b}±0.12	2.92^{b}±0.14	3.85^{a}±0.13
T4 (ng/ml)	14.64^{b}±0.20	14.76^{b}±1.21	15.06^{b}±0.31	16.80^{a}±0.25
T3/T4	0.21^{ab}±0.02	0.17^{b}±0.01	0.19^{ab}±0.01	0.23^{a}±0.01
Insulin (ng/ml)	2.14^{c}±0.11	2.03^{c}±0.19	4.34^{b}±0.09	4.79^{a}±0.18
MDA nmol/ml	0.21^{a}±0.01	0.19^{a}±0.001	0.16^{b}±0.001	0.13±0.003
SOD (U/ml)	149.69^{b}±1.60	150.43^{b}±0.75	154.88^{a}±0.47	157.45^{a}±0.35
Catalase (U/ml)	39.73^{b}±1.22	40.56^{b}±1.02	48.64^{a}±1.39	49.35^{a}±1.54

a, b and c: Means within a row with different superscripts are significantly different at ($p \leq 0.05$).

As shown in Table (7) that dietary addition of capsaicin significantly increased serum insulin, especially with the mid and high dosages. These results suggest that insulin sensitivity is increased after capsaicin treatment. Support for this thought is found by studies of Spiridonov and Vorob'eva (2002) who showed that capsaicin stimulation of rats decreased the hypoglycemic action of insulin. Also, Zhou *et al*. (1990), they found that neonatal treatment with capsaicin decreased the hypoglycemic effect of insulin. Capsaicin protected β-cell mass by increasing proliferation and decreasing apoptosis (Kwon *et al*., 2013). The levels of plasma glucose, cholesterol, and triglycerides were also lower in the capsaicin-treated mice (Lee *et al*., 2013). On the other hand, Akiba *et al* (2004) has reported that the capsaicin receptor (TRPV1) is expressed on the beta cells of the pancreas and capsaicin could induce insulin secretion from the pancreas. It has been suggested that the effect of capsaicin on insulin secretion is due to more calcium influx into the cells. Beside the effect on insulin secretion, capsaicin may decrease plasma glucose by other mechanisms since capsaicin could inhibit glucose absorption from the intestine in canines and rodents (Monsereenusorn And Glinsukon, 1980).

Lipid Peroxidation

Heat stress increased lipid peroxidation as a consequence of increased free radical generation. The rise of lipid peroxidation resulted in increased MDA level in blood and tissues (Ates *et al*., 2006). In this way, the oxidative injury induced by high ambient temperatures (Mujahid *et al*., 2006) could be reduced by the action of some antioxidants like capsaicin aimed to alleviate the negative effects of heat.

As presented in Table 7, a highly significant reduction was obtained in the serum level of (MDA), which is the primary stable by-product of lipid peroxidation, in pekin ducks whose diets were containing various capsaicin levels in particular, the mid and high levels comparable to pekin ducks fed the control diet. Interestingly, capsaicin has the ability of free radical scavenger acting to reduce lipids available for peroxidation by transferring fatty acids into the mitochondria for the production of adenosine triphosphate (ATP) through -oxidation process (Tominaga *et al*., 2001). Furthermore, it is well known that, circulating free iron is able to catalyze ROS leading to lipid membrane degradation. Capsaicin has iron-chelating properties, which may prevent the generation of ROS by binding with free iron (Dairam *et al*., 2008).

Data presented in Table 7, that dietary addition of capsaicin significantly increased serum SOD, and CAT activities especially with the mid and high dosages. Whereas, ducks whose diet was contained the low capsaicin level had slightly higher serum SOD, and CAT activities when compared with the unsupplemented control ones. In the current study, capsaicin played antioxidant roles through enhancement of SOD, and CAT activities to scavenge the overproduction of ROS generated from heat stress. Consequently, by interfering with the production of these initial ROS, capsaicin was able to abrogate the MDA levels and thereby prevent the cell membrane breakdown by ROS.

Capsaicin project different tissue from oxidative damage because its ability antioxidant capacity (Kogure *et al*., 2002). This is in agreement with Henderson et al. (1999), who showed that the amide group present in capsaicin does not play a major role in its antioxidant activity under free radical oxidation conditions, that the antioxidant behavior for capsaicin was due primarily to the phenolic moiety in the molecule, and that the main product of capsaicin oxidation is its dimersdicapsaicin. Kogure et al.

(Kogure *et al*., 2002) have found that the C-7 benzyl carbon, but not the phenolic OH group of capsaicin, is responsible for the scavenging site. Additionally, they found vanillin and 8-methyl-6-noneamide as products of capsaicin oxidative decomposition.

CONCLUSION

It is concluded that, dietary capsaicin supplementation with 100ppm up to 150ppm in Pekin ducks was sufficient to enhance the growth performance traits, thyroid activities and antioxidant system. Moreover, however, the present study pointed out that, capsaicin has the potentiality to modulate digestive enzyme activities. Further researches are needed to throw more clarification of mechanisms associated with these valuable effects.

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تاثير اضافة الكابسيسين فى العليقة على الاداء الإنتاجي والفسيولوجي للبط البيكينى خلال فصل الصيف

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الهدف من هذه الدراسة تقييم تأثير استخدام مستويات متدرجة من الكابسيسين على أداء النمو، معاملات الهضم المواد الغذائيه للعلائق، الأيض في الدم، وحالة الأكسدة وانزيمات الجهاز الهضمي والنشاط البكتيرى فى الامعاء للبط. تم تقسيم مائة وعشرين من البط البكينى عمر14يوم عشوائيا إلى أربع مجموعات من 30 بطة. تم تغذية المجموعة الأولى على عليقة أساسية (الكنترول)، تم اضافة الكابسيسين للعليقة الاساسية للمجموعات 2 و 3 و 4 بتركيزات 50 و 100 و 150 جزء في المليون من على التوالي. أظهرت النتائج تحسنا كبيرا في وزن الجسم والكفائة التحويلية للغذاء ، وخاصة مع ارتفاع مستوى (150 ppm) يليها مستوى(100 ppm) وعلاوة على ذلك إضافة الكابسيسين من مستويات مختلفة عززت قيم معاملات الهضم خصوصا مع مستخلص الايثر (EE) والمستخلص الخالي من النتروجين. اما بالنسبة لمستوى سيرم البروتينات الكلية والجلوبيولين والكوليستيرول عالى الكثافة (HDL) وهرمون ثلاثي ايودوثيرونين(T3) وهرمون الثيروكسين(T4) ، والأنزيمات المضادة للأكسدة زادت بشكل ملحوظ للبط خاصا التى تتغذى على مستويات إما 100 أو 150 ppm . ولكن تركيز الليبيدات الكلية والكوليسترول والجليسريدات الثلاثية والكوليستيرول منخفض الكثافة (LDL) والجلوكوز والمالون داى الدهايد(MDA) انخفضت فى المجاميع المضاف اليها الكابسيسين مقارنة بمجموعة الكنترول. من ناحية أخرى فإن مستوى الألبيومين لم تتأثر معنويا فى المجاميع المضاف اليها الكابسيسين. وقد وجد زيادة كبيرة في نشاط انزيمات الأميليز، والليباز والتربسين في جميع أجزاء الأمعاء الدقيقة للمجاميع المضاف اليها الكابسيسين. ويستنتج من ذلك أن إضافة الكابسيسين بتركيزات 100 ppmحتى إلى 150 ppmكان كافيا لتعزيز أداء النمو، ومعاملات الهضم ونشاط الغدة الدرقية والانزيمات المضادة للأكسدة في البط البيكينى. بالإضافة إلى أن إستخدام الإضافات الغذائية الطبيعية كان له تأثير إيجابى على النشاط الإنزيمى و التعداد البكتيري فى الأمعاء دون أى تأثير ضار على صحة الطائر ويقترح إجراء المزيد من الدراسات لتوضيح آثار إستخدام هذه الإضافات.