



Effect of Natural and Synthetic Sources of Lycopene on Productive Performance, Carcass Quality and viscera relative weights of Japanese Quail *Coturnix japonica* Temminck & Schlegel, 1849

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Abstract: This study aimed to investigate the effect of natural and synthetic sources of lycopene on performance, carcass quality and organ morphology of Japanese quail. A total of 420 one-day-old quail chicks were randomly distributed among seven treatments. First treatments were fed a basal diet as a control. Second and third treatments were fed diet supplemented with tomato fruit (*Lycopersicon esculentum*) powder (TOM) (17 and 34 g.kg⁻¹ equal to 50 and 100 mg.kg⁻¹ lycopene), fourth and fifth treatments were fed diet supplemented with red bell pepper (*Capsicum annum* L.) fruit powder (RBP) (16.23, 32.46 g.kg⁻¹ equal to 50 and 100 mg.kg⁻¹ lycopene), sixth and seventh treatments were fed diet supplemented with 50 and 100 mg.kg⁻¹ pure lycopene powder (LY), respectively. Results indicated that final body weight and weight gain were improved significantly in comparison to control and T3. Feed efficiency was improved compared to control, T3 and T7. Production and economic efficiency index significantly better than control. A significant elevation ($P \leq 0.05$) in relative weight of thigh, small intestine, duodenum, cecum weight and length for T3 treatment, T7 in jejunum and ileum weight, T4 in carcass weight and gizzard, T5 in the liver compared to control. The relative weight of abdominal fat, spleen, bursa and bursa index were decreased ($P \leq 0.05$) in supplemented treatments in comparison to control. In conclusion, natural sources of LY (50 mg.kg⁻¹) either TOM (17 g.kg⁻¹) or RBP (16.23 g.kg⁻¹), could be used to improve performance, production and economical efficiency index, carcass traits and some gut measurements of quails.

Keywords: Tomato, Red bell pepper, lycopene, Performance, Carcass quality, Quail.

Introduction

Plants and their biological active chemical constituents, present numerous opportunities for the improvement of livestock production by inclusion in the diet (Wallace *et al.*, 2010). In the human diet, fruits and vegetables are the

most important phytochemical compounds. A diet rich in fruits and vegetables is well established for its effectiveness in promoting human health, especially regulating body weight (Estruch *et al.*, 2013; Mozaffarian, 2016), On the other hand, the presence of

lycopene in tomato increasing the importance of consuming it locally and in the entire world, as well as its high nutritional value (Aziz *et al.*, 2019).

Besides that, the presence of phytochemicals in *Capsicum pepper* makes them not only useful and much cheaper alternative to synthetic drugs but the phytochemicals can be harnessed as crude drugs for the production of novel drugs (Mercy & David, 2018).

Natural plant supplements with diets of poultry can be used to enhance antioxidant defense mechanisms and reduce the intensity of oxidation processes, which negatively affect the quality of poultry products (Ognik *et al.* 2016). In this regard, Tawfeek *et al.* (2014) conducted that the use of antioxidant compounds in the feeding of broilers can improve immune function and reduce deleterious effects of reactive oxygen species (ROS) on cells. Lycopene is a carotenoid present in vegetables and ripe fruit and has been proved to be the most potent antioxidant among various common carotenoids (Sun *et al.*, 2015). Lycopene is mainly found in tomatoes and other red fruits and vegetables (Mendelová *et al.*, 2013), on the other hand, tomatoes and their products are major sources of lycopene in food (Arain *et al.*, 2018). According to Abdullah *et al.* (2019), the Jordanian vine tomato dried waste has a substantial amount of lycopene with twice oxidative scavenging power of that of ascorbic acid.

Palozza *et al.* (2012) reported that lycopene scavenges ability was twice than α - tocopherol and ten times higher than β -carotene. The previous study has focused on carotenoids, which are fat-soluble antioxidants found in peppers due to their antioxidant properties (Rao

& Rao, 2007) and such as their provitamin A activity, antioxidant action, immune modulation and involvement in cell signaling (Tundis *et al.*, 2011). Additionally, lycopene has activated antioxidant enzymes and nuclear transcription factor systems in heat-stressed broilers (Sahin *et al.*, 2016). Several studies reported health-promoting and antioxidant potentials of lycopene natural sources. In this regard; Sahin *et al.* (2008) revealed that lycopene-rich tomato powder significantly improved feed consumption, body weight gain and decreased concentration of malondialdehyde (MDA) in muscles, liver and serum of Japanese quail reared under heat stress.

Selim *et al.* (2013) reported that dietary inclusion of lycopene-enriched tomato by-products at a level of 1% in broilers feed under heat stress enhanced total antioxidant capacity and lowered MDA level. Recently, Mezbani *et al.* (2019) reported that lycopene (100 mg.kg⁻¹) improved performance and antioxidant status of broilers. On the other hand, a study on Novogen white laying hens shows that diet supplemented with ground linseed (4.5%), dried tomato pastes (1%) and sweet pepper powder (1%) mix increased the Roche yolk colour fan score and redness of egg yolk colour (Omri *et al.*, 2019). Therefore, the objective of this study was to determine the effect of lycopene from natural and synthetic sources on the performance of Japanese quail birds.

Material & Methods

Experimental birds and treatments

The experiment was conducted in Quail Farm, Department of Animal Production, College of Agriculture, University of Basrah during the period from 19/3/2018 to 7/5/2018. A total of

420 one-day-old of Japanese quail was randomly allocated to seven treatments, three replicates and 20 birds per replicate according to the Completely Randomized Design. All chicks reared in cages (replicates) with dimensions (60 × 70 × 60) cm. The chicks were allowed free access to feed and water and fed the basal diet formulated to meet the nutrient requirements of quail. The following seven dietary treatments were prepared by adding various levels of dried tomato fruit (*Lycopersicon esculentum*) powder (TOM) and red bell pepper fruit (*Capsicum annuum* L.) powder (RBP) to the basal diet as a source of natural lycopene, the content of which was previously estimated from lycopene (Table 2). Experimental diets were designed as follows: First treatment were fed a basal diet (BD) as a control. Second and third treatments were fed diet supplemented with tomato fruit (*Lycopersicon esculentum*) powder (TOM) (17 and 34 mg.kg⁻¹ equal to 50 and 100 mg.kg⁻¹ lycopene, respectively). Fourth and fifth treatments were fed diet supplemented with red bell pepper (*Capsicum annuum* L.) fruit powder (RBP) (16.23, 32.46 g.kg⁻¹ equal to 50 and 100 mg.kg⁻¹ lycopene. The sixth and seventh treatments were fed diet supplemented with 50 and 100 mg.kg⁻¹ pure lycopene powder (LY), respectively.

The fruits of tomato and red sweet pepper used in this study were provided by local Liveability percentage = 100 – mortality percentage

The economic efficiency index (EEI) was calculated according to Naji (2006):

$$\text{Economic efficiency index (EEI)} = \frac{\text{Average of live weight in (kg)} \times \text{liveability percentage} \times 100}{\text{Age in days} \times \text{FCR}}$$

producers. Fruits of both tomato and red peppers were dried in the shade, ground into a fine powder using an electric dry mill, and then powders were stored in black plastic bags at room temperature (25°C). With the beginning of the experiment, fruit powder was added to the basal diet at various levels. Lycopene pure powder used in this experiment was purchased from (Shaanxi Jintai Biological Engineering Company-China). The ingredients and chemical composition of the basal diet were shown in table (1). Chemical analysis of TOM and RBP fruit powder was carried out according to AOAC (2016). The amount of lycopene was estimated according to the method of Markovic *et al.* (2006) (Table 2). The chicks were fed a starter diet until 21 days of age, followed by a grower diet from 22 to 49 days. All chicks were kept under uniform management conditions throughout the experiment period of 49 days. Live body weight (LBW) was determined through the period of a starter and finisher. Feed intake (FI) was recorded for the corresponding periods and feed efficiency ratio (FCR) was calculated. Production Index (PI) was calculated according to the equation of Naji (2006):

$$\text{Production index (PI)} = \frac{\text{Average of live weight in (gm)} \times \text{liveability percentag}}{\text{Age in days} \times \text{FCR} \times 10}$$

Table (1): Ingredients and nutrient composition of quail starter and grower diets.

Ingredient (%)	Starter diet 1-21 day	Grower diet 22-49 day
Yellow corn	50.00	56.00
Wheat	8.50	8.50
Soybean meal (44%)	33.00	28.00
¹ protein concentrates (44%)	6.00	5.00
Vegetable oil	1.00	1.00
Dicalcium phosphate	0.25	0.25
Limestone	0.75	0.75
² Mineral premix	0.25	0.25
Sodium chloride	0.25	0.25
Total	100	100
Calculated composition ³		
Metabolizable energy (kcal.kg ⁻¹)	2934	2995
Crude protein (%)	22.60	20.47
Crude fat (%)	3.10	3.08
Crude fibre (%)	3.61	3.53
Calcium (%)	0.74	0.68
Phosphorus available (%)	0.35	0.32
Lysine (%)	1.16	1.07
Methionine (%)	0.42	0.39
Methionine + Cysteine (%)	0.77	0.73
Calorie: protein ratio	129.82	146.31

¹Protein concentrate used from Al-Hayat Company, Jordanian Origin, to provide the following per kg of diet: 44% protein, 2800 kcal.kg⁻¹ME, 12% fat, 25% ash, 5% calcium, 2.9% phosphorus, 2.55% methionine + Cysteine, 2.8% lysine.²Content/kg: Manganese 80 g; iron 80 g; zinc 50 g; copper 10 g; cobalt 2 g; Iodine 1 g; excipient q.s - 1,000 g. ³Was calculated according to the chemical composition of feedstuff contained in NRC (1994).

Table (2): Proximate analysis and lycopene content of tomato and red bell pepper Fruits (% on a dry weight basis).

Component (%)	Tomato powder	Red bell pepper
Dry matter	85.08	91.52
Crude protein	14.53	13.13
Crude fat	3.71	11.47
Ash content	8.36	6.72
Crude fibre	10.60	23.90
Available carbohydrate	62.80	44.78
Organic matter	91.64	93.28
Metabolized energy(Kcal.kg ⁻¹)*	2793.86	2729.04
Lycopene (mg.100g ⁻¹)	293.58	307.99

*ME was calculated according to Lodhi *et al.* (1976).

Carcass and internal weights evaluation

At the end of the seventh-weeks experiment, three birds of similar body weight from each treatment group were used to study slaughter traits. The birds were randomly selected, individually weighed and slaughtered. Different internal organs were collected, weighed and expressed as a percentage of the live body weights. Weight of liver, heart, gizzard, spleen, bursa of fabricius, abdominal fat, small intestine, duodenum, Jejunum and ileum were measured. The length of the gastrointestinal tract consists of small intestinal, duodenum, jejunum, ileum and the cecum was also measured and recorded and expressed as a percentage of the live body weights. The relative weights of carcasses cut (breast and thigh) were expressed as a percentage of carcass weight. Dressing percentage was calculated according to the equation of Al-Fayadh *et al.* (2011):

$$\text{Dressing percentage} = \frac{\text{Dressed weight (gm)}}{\text{Live weight (gm)}} \times 100$$

Bursa index was calculated by dividing the weight of bursa of fabricius gland for each treatment group by the weight of the gland for the control group (Lucio & Hitchner, 1979).

Statistical analysis

All data were subjected to a one-way ANOVA procedure by using SPSS program software (2012) significant treatment means were separated by using the Least Significant Difference (L.S.D.) test at $P \leq 0.05$.

Results & Discussion

Production performance

The effect of dietary supplementation with tomato fruit powders (TOM), the red bell pepper fruit powders (RBP) and pure lycopene (LY) on the productive performance of quail chicks are presented in table (3). The result revealed that the experimental treatments supplemented with TOM (17 g.kg⁻¹) RBP and LY, that final body weight and total weight gain were improved significantly ($P \leq 0.05$) in comparison to control and T3. The feed conversion ratio was improved ($P \leq 0.05$) as compared to control, T3, and T7, meanwhile all supplemented treatments did not affect the total feed intake. The improvement in final body weight, total weight gains and cumulative feed conversion ratio (in T2, T4, T5 and T6) for supplementary treatments may be due to presences of lycopene in additive materials and its role as a strong antioxidant in reducing oxidative stress and protecting cells from free radicals that lead to oxidation of saturated fatty acids and damage to the cell membrane (Rao & Agarwal, 1999). It is well known that rapid growth rates and improve feed conversion lead to high oxidative stress in birds and that lycopene plays an important role in strengthening the body's antioxidant defense system (Ševčíková *et al.*, 2008; Khan *et al.*, 2014). Moreover, lycopene is a powerful antioxidant that able to reduce the harmful effects of free radicals and prevent oxidation of fat, proteins and nucleic acids, and that the improvement in productive traits may be related to its antioxidant properties (Wang, 2012). Also, the improvement in growth performance (body weight and weight gain) may have been linked to its antioxidant feature (Rao &

Table (3): Effect of dietary tomato, red bell pepper fruits powder and lycopene on the overall (1-7 wks.) performance Japanese quail.

Parameters	Dietary treatments							Sig.
	T1	T2	T3	T4	T5	T6	T7	
Initial live weight (g)	26.71± 0.21	27.07± 0.38	27.63± 0.27	28.30± 0.96	27.03± 1.04	27.77± 0.50	27.07± 0.94	NS
Final body weight (g)	179.14 ^d ± 1.13	192.89 ^{ab} ± 1.95	184.27 ^{cd} ± 0.44	191.03 ^b ± 2.99	196.82 ^a ± 0.90	193.20 ^{ab} ± 0.69	188.15 ^{bc} ± 2.50	*
Body weight gain (g)	152.44 ^d ± 0.92	165.83 ^{ab} ± 1.99	156.64 ^{cd} ± 0.22	162.73 ^b ± 3.02	169.79 ^a ± 1.94	165.43 ^{ab} ± 1.19	161.09 ^{bc} ± 2.43	*
feed intake, g/bird	780.00± 11.89	747.72± 16.45	749.19± 24.79	763.51± 32.39	732.18± 11.11	756.75± 33.20	769.06± 10.10	NS
Feed efficiency (g.g ⁻¹)	4.354 a± 0.087	3.875bc± 0.093	4.064abc± 0.124	3.996bc± 0.171	3.719c± 0.065	3.914bc 0.016	4.086ab± 0.032	*
Production index	8.47 ^c ± 0.26	10.16 ^a ± 0.30	9.26 ^b ± 0.25	9.78 ^b ± 0.40	10.80 ^a ± 0.22	10.09 ^{ab} ± 0.39	9.26 ^b ± 0.05	*
Economic efficiency index	254.84 ^a ± 8.99	174.18 ^b ± 7.87	183.03 ^b ± 12.03	183.65 ^b ± 15.71	159.95 ^b ± 6.14	178.68 ^b ± 15.05	188.44 ^b ± 3.04	*
Mortality	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NS

^{abc}Means in the same row with no common superscript are different significantly ($P \leq 0.05$). NS: None significant, T1 (control), T2 and T3 (Tomato fruits powder at the levels of 17 and 34 g.kg⁻¹ in basal diet), T4 and T5 (Red bell pepper at the levels of 16.23 and 32.46 g.kg⁻¹ in basal diet) which was equivalent to 50 and 100 mg.kg⁻¹lycopene respectively, T6 and T7 (lycopene powder at the levels of 50 and 100 mg.kg⁻¹ in basal diet) respectively.

Agarwal, 1999; Wang, 2012). Besides, the consumption of tomato and its species lead to improve digestion and increase absorption as a result of increased secretion and activity of the digestive system, this is due to palatability and its high content of antioxidants and nutrients (Zhao *et al.*, 2011; Asadollahi *et al.*, 2014). As well as, this improvement in growth

performance may be due to the positive effect of lycopene on gut physiology in broiler chickens (Sun *et al.*, 2015).

Shehata *et al.* (2018) confirmed that the addition of tomato pomace by 5% without enzymes to quail diets increased final weight of 29.36% as compared to control at 42 days of

age. The findings of the present study for body weight and body weight gain were in line with previous researches in broilers (Ali & Al Massad, 2015; Sahin *et al.*, 2016), quails (Shehata *et al.*, 2018) and geese (Al-Janabi, 2015), who found a positive effect on growth performance when tomato and tomato residuals and lycopene used in poultry ration. On the other hand, in broilers, weight gain, feed intake and feed efficiency did not change significantly with the inclusion of 10 and 20 (mg.kg⁻¹) of lycopene or 17 (g.kg⁻¹) of tomato paste (which was equivalent to 5 ppm of lycopene) in experiment lasted four weeks (Lee *et al.*, 2016). In this respect, Marzoni *et al.* (2014) revealed that the inclusion of tomato skins extracts, which contained 200 mg of lycopene per kg of diet did not affect the growth performance of broiler chickens. As well as, a study conducted by Dougnon *et al.* (2014) mentioned the supplementation of the diet with pepper (*Capsicum frutescens*) powder at 0.5 and 1% for one or two months had no noticeable effect on weight gain, feed consumption and feed conversion ratio of Hubbard broilers.

Regarding feed intake, our result supported the finding of the previous study, Sahin. *et al.* (2006) found no significant effect of lycopene on feed consumption of broiler chicks. The production index (PI) and economic efficiency index (EEI) are shown in table (2). The production index (PI) and economic efficiency index (EEI) are shown in table (2). Production and economic efficiency index significantly were better ($P \leq 0.05$) than control. Regarding for EEI, the results indicated that there was a significant decreased ($P \leq 0.05$) in EEI values of supplemented treatments as compared to control, which reflect the best economic

efficiency value. The better feed conversion ratio in supplement treatments and the absences of mortality positively reflected on the improvement in PI and EEI. Also, the improvement in PI and EEI may be due to the presence of natural sources of lycopene from tomato powder, red bell pepper and synthetic lycopene in diets. The consequent increase of fats digestion and other nutrients resulted in exceeded body weight, weight gain, feed conversion ratio and low mortality rate (North, 1984).

Likewise, the improvement in the PI and EEI may be due to lycopene as a natural antioxidant that plays an important role inside and outside the cell in increasing utilization of nutrients, which is reflected on the improvement in productive performance of growing quail (Flint & Garner, 2009). No quail chicks' deaths were observed throughout the experimental period. The effect of TOM, RBP and LY supplementation on carcass characteristics of quails aged 49 days are presented in table (4).

There was a significant difference ($P \leq 0.05$) in carcass weights, the relative weight of thigh, liver and gizzard. Birds fed on diets supplemented with (16.23 g.kg⁻¹) RBP gave significantly ($P \leq 0.05$) the heaviest carcass weights compared to control and with TOM treated groups T2 and T3 (17 and 34 g.kg⁻¹) respectively. These results are consistent with the increasing of growth rates which resulted in heavier slaughter weight, liver and gizzard. Birds fed on diets supplemented with (16.23 g.kg⁻¹) RBP (T4) gave significantly ($P \leq 0.05$) the heaviest carcass weights compared to control and with TOM treated groups T2 and T3 (17 and 34 g.kg⁻¹) respectively. These results are consistent with the increasing of

Table (4): Carcass characteristic at 49 days of the age of Japanese quail received tomato, red bell pepper fruits powder and lycopene in diets.

Parameters	Dietary treatments							Sig ·
	T1	T2	T3	T4	T5	T6	T7	
Carcass weight (g)	118.32 ^{b±} 10.69	120.36 ^{b±} 2.87	113.88 ^{b±} 2.42	139.12 ^{a±} 3.27	121.24 ^{ab} ± 4.07	122.19 ^{ab±} 10.02	127.28 ^{ab} ± 1.19	*
Carcass yield (%)	62.52± 5.02	67.83± 6.13	64.39± 5.41	72.43± 1.27	64.51± 1.38	64.98± 4.40	70.83± 4.01	NS
Breast yield (%)	32.90± 3.32	29.28± 2.74	30.28± 2.10	32.29± 1.55	33.02± 1.42	34.65± 1.01	31.27± 0.16	NS
Thigh yield (%)	10.98 ^{ab±} 0.30	11.21 ^{ab±} 0.67	11.91 ^{a±} 0.57	11.45 ^{ab±} 0.10	11.82 ^{ab±} 0.20	10.75 ^{b±} 0.10	11.46 ^{ab±} 0.18	*
Liver yield (%)	1.81 ^{b±} 0.3	2.68 ^{a±} 0.42	2.04 ^{ab±} 0.46	2.68 ^{a±} 0.207	2.98 ^{a±} 0.34	2.84 ^{a±} 0.49	2.45 ^{ab±} 0.62	*
Heart yield (%)	0.78± 0.11	0.92± 0.09	0.78± 0.09	0.98± 0.06	0.78± 0.03	0.88± 0.09	0.84± 0.07	NS
Gizzard yield (%)	1.34 ^{b±} 0.15	1.57 ^{ab±} 0.11	1.46 ^{ab±} 0.01	1.76 ^{a±} 0.20	1.54 ^{ab±} 0.11	1.51 ^{ab±} 0.084	1.76 ^{a±} 0.16	*

^{ab} Means in the same row with no common superscript are different significantly ($P \leq 0.05$). NS: None significant, T1 (control), T2 and T3 (Tomato fruits powder at the levels of 17 and 34 g.kg⁻¹ in basal diet), T4 and T5 (Red bell pepper at the levels of 16.23 and 32.46 g.kg⁻¹ in basal diet) which was equivalent to 50 and 100 mg.kg⁻¹ lycopene respectively, T6 and T7 (lycopene powder at the levels of 50 and 100 mg.kg⁻¹ in basal diet) respectively.

growth rates which resulted in heavier slaughter weight. These results are consistent with the increasing of growth rates which resulted in heavier slaughter weight. The result showed a significant elevation ($P \leq 0.05$) in the relative weight of thigh for T3 treatment, T4 in carcass weight and gizzard, T5 in the liver as compared with control. The improvement in the carcass weight may be due to the improved in body

weight (Table 3) and that there is a linear relationship between carcass weight and body weight (Al-Fayadh & Naji, 1989), which positively reflect the weight of thighs, liver and gizzard.

Also, this improvement may be due to the role of lycopene in enhancing digestive enzyme activities, which increase the efficiency of

nutrients use, rapid growth and organs development, and body weight (Jang & Moon, 2015). Similarly, with the present results, Leke *et al.* (2018) indicated that adding dry tomato powder to broiler diet by 12% led to an increase in carcass weight. On the contrary to our results; Lee *et al.* (2016) found no significant effect of lycopene at the levels of 10 or 20 mg.kg⁻¹ or 17 g.kg⁻¹ of tomato paste which was equivalent to 5 ppm of lycopene on relative Gastrointestinal traits (GIT) and internal organ of the experimental treatments in Japanese quail at 49 are shown in table (5). GIT relative weight and length, jejunum and ileum parts, small intestine and duodenum length were not differed respecting all treatments. There was a significant difference ($P \leq 0.05$) in relative weight and length of the small intestine, duodenum, jejunum, ileum parts, cecum and with the relative weight of abdominal fat, spleen, bursa of fabricius and bursa index.

Result showed a significant elevation ($P \leq 0.05$) in the relative weight of small intestine for T6 treatment, T3 in duodenum, T7 in jejunum and ileum as compared with control. As regards to cecum weight and length, quails in T3 gave significantly ($P \leq 0.05$) the highest rates as compared with control. Abdominal fat, spleen, bursa of fabricius relative weight and bursa index were declined in all dietary groups in comparison with the control one, except T6 in spleen and T2 and T3 in the bursa of fabricius, which equal to control. The decline in the relative weight of spleen and bursa of fabricius recorded in the current study was positive evidence of animal health. This evidence indicates that the sources of lycopene

in experimental treatments contributed to improving the immunity of birds, which reflected positively on the absence of birds' mortality. The most important mechanism of lycopene to preserve animal health is enhancing the immunity system by preventing the synthesis of cytokines or mineral correlated proteins responsible for inflammation (Vitale *et al.*, 2010).

This evidence indicates that the sources of lycopene in experimental treatments (TOM, RBP and LY) contributed to improving the immunity of birds, which reflected positively on the absence of birds' mortality. The most important mechanism of lycopene to preserve animal health is enhancing the immunity system by preventing the synthesis of cytokines or mineral correlated proteins responsible for inflammation (Vitale *et al.*, 2010).

Our results coincided with the finding of El-Tazi (2014) who showed the lowest percentage of abdominal fat and the highest percentages of liver and gizzard due to the consumption of mixture diet ratio of red and black peppers at 1% in comparison with the control. Also, Ševčíková *et al.* (2008) showed the broiler chickens fed 50-100 mg lycopene. kg⁻¹ feed, the lycopene treatments achieved the lowest fat percentage in breast cuts. On other hands, Al-Shammary (2017) reported that the supplementation of zinc and lycopene at a level of 30 and 200 mg.kg⁻¹ in quail diet respectively, resulted in a significant improved in carcass yield, liver and breast weight, gastrointestinal tract and small intestine lengths, histological characteristics of the duodenum and reduced abdominal fat at the age of 42 days.

Table (5): Effects of different levels of tomato, red bell pepper fruits and lycopene powder in diets on some gastrointestinal traits and internal organ in Japanese quail at 49 days of age.

Parameters (%)	Dietary treatments							Sig.
	T1	T2	T3	T4	T5	T6	T7	
Gastrointestinal tract weight %	4.12± 0.51	4.40± 0.63	4.96± 1.01	3.87± 0.31	3.68± 0.27	3.78± 0.19	4.62± 0.16	NS
Gastrointestinal tract length (%)	64.33± 6.84	63.00± 6.80	55.33± 1.45	68.00± 5.77	66.33± 6.84	61.33± 4.33	60.00± 1.15	NS
Small intestine weight (%)	1.31 ^b ± 0.08	2.25 ^{ab} ± 0.08	2.60 ^a ± 0.52	2.19 ^{ab} ± 0.38	2.30 ^{ab} ± 0.36	2.63 ^a ± 0.43	2.85 ^a ± 0.47	*
Small intestine length (%)	22.84± 3.28	22.92± 0.79	22.22± 1.88	21.89± 2.39	22.48± 1.98	22.14± 1.36	23.11± 0.78	NS
Duodenum weight (%)	0.81 ^b ± 0.06	1.15 ^{ab} ± 0.28	1.70 ^a ± 0.33	1.22 ^{ab} ± 0.35	1.29 ^{ab} ± 0.34	1.60 ^{ab} ± 0.21	1.65 ^a ± 0.19	*
Duodenum length (%)	6.87± 0.27	6.78± 0.80	7.57± 0.87	6.95± 0.87	6.23± 0.45	6.22± 0.25	7.25± 0.63	NS
Jejunum and ileum weight (%)	0.50 ^b ± 0.01	1.13 ^a ± 0.12	1.01 ^{ab} ± 0.22	0.96 ^{ab} ± 0.20	1.00 ^{ab} ± 0.06	0.96 ^{ab} ± 0.19	1.19 ^a ± 0.27	*
Jejunum and ileum length (%)	17.73± 2.64	15.95± 0.08	14.99± 0.72	14.93± 2.66	16.24± 0.72	15.92± 1.57	15.69± 0.78	NS
Cecum weight (%)	0.84 ^b ± 0.05	0.86 ^b ± 0.09	1.79 ^a ± 0.68	0.94 ^{ab} ± 0.21	0.85 ^b ± 0.29	0.69 ^b ± 0.18	1.55 ^{ab} ± 0.05	*
Cecum length (%)	10.51 ^d ± 0.96	11.70 ^{bc} ± 0.85	14.10 ^a ± 0.96	10.86 ^{cd} ± 0.60	12.98 ^{abc} ± 0.57	10.90 ^{cd} ± 0.40	13.59 ^{ab} ± 0.47	*
Abdominal fat weight (%)	1.02 ^a ± 0.01	0.69 ^b ± 0.07	0.70 ^b ± 0.11	0.69 ^b ± 0.10	0.63 ^b ± 0.02	0.64 ^b ± 0.06	0.78 ^b ± 0.06	*
Spleen weight (%)	0.08 ^a ± 0.003	0.06 ^b ± 0.007	0.06 ^b ± 0.006	0.06 ^b ± 0.006	0.06 ^b ± 0.004	0.07 ^{ab} ± 0.007	0.06 ^b ± 0.005	*
Bursa of fabricius weight (%)	0.40 ^a ± 0.05	0.34 ^{ab} ± 0.03	0.35 ^{ab} ± 0.01	0.27 ^{bc} ± 0.03	0.31 ^{bc} ± 0.02	0.25 ^{bc} ± 0.02	0.22 ^c ± 0.01	*
Bursa index	1.00 ^a ± 0.00	0.81 ^b ± 0.00	0.84 ^b ± 0.03	0.70 ^{bc} ± 0.09	0.77 ^{bc} ± 0.02	0.62 ^{cd} ± 0.05	0.54 ^d ± 0.04	*

^{abcd} Means in the same row with no common superscript are different significantly ($P \leq 0.05$). NS: None significant, T1 (control), T2 and T3 (Tomato fruits powder at the levels of 17 and 34 g.kg⁻¹ in basal diet), T4 and T5 (Red bell pepper at the levels of 16.23 and 32.46 g.kg⁻¹ in basal diet) which was equivalent to 50 and 100 mg.kg⁻¹ lycopene respectively, T6 and T7 (lycopene powder at the levels of 50 and 100 mg.kg⁻¹ in basal diet) respectively.

Our results are close to Rahmatnejad *et al.* (2011) except for carcass weight, thighs, liver and gizzard, who reported that supplementation of dried tomato pomace up to 8% broiler diets had comparable carcass weight, carcass yield, breast, thigh, abdominal fat, heart, liver and gizzard with those of control group.

The significant improvement of supplemented groups in the relative weight of small intestine and its parts may be due to lycopene role in improved palatability and increased digestibility, as a result of the increasing and secretion activity enzymes in the digestive system (Zhang *et al.*, 2009). In addition to the improvement in the bodyweight of quails, it reflected positively on the relative weight of cecum, besides the presence of the fibre in cecum increasing the size of this organ compared to the other organs (Nikolakakis *et al.*, 2004), because microbial digestion of cellulosic substances occur

Conflicts of interest

The authors declare that they have no conflict of interests.

Ethical approval

All applicable institutional, national and international guidelines for the care and use of animals were followed.

Conclusion

It could be concluded that the supplementation of fruit powders of tomato (17g.kg⁻¹) and red bell pepper (16.23 g.kg⁻¹) as a natural source of pure lycopene (50 mg.kg⁻¹), led to an improvement in the productive performance, production index, economic efficiency index, carcass traits and some gut measurements of Japanese quail.

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تأثير المصادر الطبيعية والصناعية لليكوبين في الأداء الإنتاجي وصفات الذبيحة ووزن الاحشاء النسبي في السمان الياباني *Coturnix japonica*

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المستخلص: هدفت الدراسة لمعرفة تأثير المصادر الطبيعية والصناعية لليكوبين في الأداء الإنتاجي وصفات الذبيحة ومورفولوجيا الأعضاء في السمان الياباني (*Coturnix japonica*). تم توزيع 420 فرخاً غير مجنس بعمر يوم واحد من طيور السمان الياباني عشوائياً على سبع معاملات تجريبية وبواقع ثلاث مكررات للمعاملة الواحدة و 20 فرخاً لكل مكرر. تناولت المعاملة الاولى العليقة الاساسية واعتبرت معاملة سيطرة. وأضيف مسحوق ثمار الطماطم الى العليقة الاساسية بالمستويين 17 و 34 (غم.كغم⁻¹) بالمعاملة الثانية والثالثة لتجهيز 50 و 100 (ملغم.كغم⁻¹) ليكوبين على التوالي، ومسحوق الفلفل البارد الاحمر الى العليقة الاساسية بالمستويين 16.23 و 32.46 (غم.كغم⁻¹) بالمعاملة الرابعة والخامسة لتجهيز 50 و 100 (ملغم.كغم⁻¹) ليكوبين على التوالي. وتم اضافة مسحوق اليكوبين النقي (الصناعي) بالمستويين 50 و 100 (ملغم.كغم⁻¹) الى العليقة الاساسية في المعاملتين السادسة والسابعة على التوالي. أشارت النتائج حصول تحسن معنوي ($P \leq 0.05$) في وزن الجسم النهائي والزيادة الوزنية التراكمية مقارنة بمعاملة السيطرة و T3، وتحسن معنوي في كفاءة التحويل الغذائي مقارنة بالسيطرة و T3 و T7. وتحسنت قيم الدليل الإنتاجي والكفاءة الاقتصادية معنوياً مقارنة بالسيطرة. وظهر تأثير معنوي في وزن الذبيحة والوزن النسبي للفخذ والكبد والقانصة والأمعاء الدقيقة والاثني عشر وجزئي الصائم واللفائفي ووزن الاعورين وطوليهما. حصلت زيادة معنوية ($P \leq 0.05$) في الوزن النسبي للفخذ والأمعاء الدقيقة والاثني عشر ووزن الاعورين وطوليهما في T3، وفي وزن جزئي الصائم واللفائفي في T7، وفي وزن الذبيحة والقانصة في المعاملة الرابعة وفي وزن الكبد في T5 مقارنة مع السيطرة. في حين حصل انخفاض معنوي ($p \leq 0.05$) في الوزن النسبي للطحال وطبقة دهن البطن وفي دليل غدة فابريشيا لجميع معاملات الاضافة مقارنة بالسيطرة. نستنتج من الدراسة الحالية امكانية استخدام المصادر الطبيعية لليكوبين (50 ملغم.كغم⁻¹)، اما مسحوق ثمار الطماطم (17 غم.كغم⁻¹) أو مسحوق الفلفل البارد الاحمر (16.23 غم.كغم⁻¹)، لتحسين الاداء، الدليل الإنتاجي، الكفاءة الاقتصادية، صفات الذبيحة، الوزن النسبي للأمعاء الدقيقة، الاثني عشر وجزئي الصائم واللفائفي لطيور السمان.

الكلمات المفتاحية: الطماطم، الفلفل البارد الأحمر، الليكوبين، الأداء، صفات الذبيحة، السمان.