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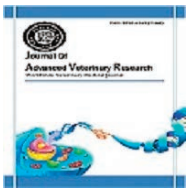

Behavior, Fear Response, Performance, Carcass Characteristics and Economic Efficiency of Fayoumi Chicks Fed Different Levels of Fennel Seeds

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ABSTRACT

The study objective was to evaluate the effects of fennel seeds (*Foeniculum vulgare*) as a dietary additive on some behaviors, fear response, performance, carcass traits, serum metabolites and economic efficiency of male fayoumi chickens. For this purpose, 60 birds of 28 days of age were divided into control group and three treatment groups. Each group (5 birds x 3 replicates). The fennel seeds were added to the treatment diets at concentrations of 0.4, 0.8, and 1.2%, respectively. Result showed that, fennel seeds treated groups had significant difference ($P<0.05$), and showed higher feed intake, ingestive and comfort behavior, production efficiency index, body weight, weight gain, relative economic efficiency, serum total protein and globulin. While, had lower aggressive behavior and fear response than birds on fennel free diet. On the other hand, no changes in feed conversion, relative growth rate, dressing percentage and internal organ relative weight, serum calcium and phosphorus levels due to fennel addition. It could be concluded, that fennel seeds have a growth stimulatory effect, improving behavior, fear response, economic efficiency and general health status of male fayoumi chickens.

Introduction

Fayoumi chicken is the most important Egyptian native type and spread to many countries worldwide. Its represents an important genes source for research purposes and for future breeding. It has ability to adapt in local environment; with a natural resistance to some diseases and stressful effects (Kolstad and Abdou, 2000). Growth-promoting feed additives are qualified as substances that added to the animals feed in minor quantities to exert desirable properties or to restrain undesirable ones. Hence, improving growth performance, live weight gain and feed conversion efficiency and lower mortality rates (Steiner, 2006).The use of sub-therapeutic levels of antibiotic growth promoters (AGPs) sustained in practice for many decades until questioned for increasing concerns to antibiotic resistance and lessening the efficacy of antibiotics that are used for medical purposes (Dibner and Richards, 2005; Kabir, 2009).

Recently, some feed additives such as probiotics, prebiotics, symbiotic, organic acids, enzymes and phytogenic are used as a replacement for AGP (Hassan and Raheem, 2016; Upadhaya and kim, 2017; Mohamed *et al*., 2018; Hassan and El Shoukary, 2019). The phytogenic feed additives (PFA) are derived from herbs, spices and aromatic plant. These are reported to have a wide range of activities including antioxidant, anthelminthic, antimicrobial, antiviral, antifungal, anti-coccidial properties, and also can act as a growth enhancer and immune modulator (Upadhayay *et al*., 2012; Gopi *et al*., 2014; Abd El- Hack and Alagawany, 2015).

The fennel (Foeniculumvalgare) belongs to Family: Apiaceae commonly known as shamar. The seeds contain health-promoting essential oils as anethole, limonene, anisic aldehyde, pinene, myrcene, fenchone, chavicol, and cineole as well as flavonoids, aminoacids, fatty acids and phenolic compound (Kiczorowska *et al*., 2015; Al-Yasiry and Kiczorowska, 2016). Fennel seeds (FS) also have antioxidant, antimicrobial, anti-inflammatory, antispasmodic, and antipyretic properties, concentrated source of several minerals (copper, calcium, phosphorus) and many vital vitamins such as vitamin A, E, C and B-complex (Rather *et al*., 2016; Lupu *et al*., 2019; Khalil and Hussein, 2020).

According to the authors knowledge, there are no available research study the effects of fennel seed on behavior, welfare, performance traits, carcass indices, digestive organs,

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serum parameters and economic efficiency on fayoumi broiler. Therefore, the current study aimed to evaluate the potency of different dietary fennel levels as natural growth promoters on those parameters.

Materials and methods

Fennel seeds

Fennel seeds were purchased from local herbal market and analyzed in Faculty of Science, at Assiut University, Egypt and according to method of Betts (1992) and Adams (1995).

Birds, treatments and management

A total number of 60 one-month-old fayoumi broilers chicken, purchased from a local commercial hatchery were randomly divided into 4 dietary treatments with 3 replicates of 5 birds based on a completely randomized design. The birds reared in same size deep wood shaving litter system pens. Four experimental diets were formulated from commercially available ingredients (Table 1), composed of 0% FS, which was served as the control (Con), while, the other three diets contained 0.4, 0.8 and 1.2% FS (FS1, FS2 and FS3, respectively). The experimental diets were used in mash form and formulated according to (NRC, 1994 and Khawaja *et al*., 2012). Environmental temperature and lighting program were adjusted according to the commercial recommendations. The light was provided 24 h per day. The ambient temperature was constant at 25◦C. All procedures and protocols were agreed by the Faculty of Veterinary Medicine, Assiut University, Egypt.

Feed analysis

The chemical analysis was performed for the dietary ingredients to assess dry matter (DM), ether extract, crude protein, and ash, while nitrogen free extract was calculated according to the methods of Association of Official Analytical Chemists (AOAC, 2011). The metabolized energy (ME) content of the experimental diets was calculated based on chemical composition (NRC, 1994).

Animal performance

Individual and cumulative body weight and feed intake birds per replicate was recorded weekly. The feed conversion ratio (FCR) per replicate was calculated at weekly intervals by taking into consideration the weekly body weight gains and the feed consumption of the respective replicate. European Production efficiency index (EPI) and relative growth rate (RGR) were calculated according to Marcu *et al*. (2013) and Gondwe and Wollny (2005) respectively.

Behavioral observations

Fayoumi broilers were directly observed in two periods / day, in the morning (7.00- 9 am) and in the afternoon (13.00-15.00 pm) for two un-consecutive days / week for 5 consecutive weeks. Each period was 10 minutes which analyzed by using a scanning technique (Fraser and Broom, 1990). The number of chicks engaged in ingestive behavior (feeding and drinking), comfort behaviors (resting, preening, wing/leg stretching and dust bathing), and aggressive behaviors (pecking, and threatening) was recorded. Then percentage of chicks engaged in each behavior was calculated during all scan samples.

Tonic immobility test (fear test)

Tonic immobility test (TIT) were performed in the last week of the experiment and done on three birds per replicate for 5

Table 1. ingredients (%) and nutrient composition of experimental diets.

Ingredients (%)	Treatments			
	Con	FS1	FS2	FS3
Corn	68	67.6	67.2	66.8
Soybean meal	28	28	28	28
Sunflower oil	0.5	0.5	0.5	0.5
Fennel seeds	0	0.4	0.8	1.2
Limestone	1.77	1.77	1.77	1.77
Sodium phosphate dibasic	1.1	1.1	1.1	1.1
Methionine	0.03	0.03	0.03	0.03
Salt	0.3	0.3	0.3	0.3
Premix *	0.3	0.3	0.3	0.3
Total	100	100	100	100
Calculated analysis (%)				
Crude protein	18.52	18.48	18.45	18.41
Crude fiber	3.27	3.26	3.25	3.24
Calcium	0.8	0.8	0.8	0.8
Available phosphorus	0.3	0.3	0.3	0.3
Methionine	0.32	0.32	0.32	0.32
Lysine	0.93	0.93	0.93	0.93
Arginine	1.13	1.13	1.13	1.13
Threonine	0.68	0.68	0.68	0.68
Tryptophan	0.25	0.25	0.25	0.25
Energy content:				
ME (kcal/kg diet)	2951	2937	2923	2910

Con; control group fed basal diet; FS1, group fed basal diet supplemented with 0.4% FS; FS2, group fed basal diet supplemented with 0.8% FS and FS3, group fed basal diet supplemented with 1.2% FS.

*Each one kg contains: Vit. A, 6250000 IU; Vit. D3, 2500000 IU; Vit. E, 25000 mg; Vit. K3, 1750 mg; Vit. B1, 500 mg; Vit. B2, 2750 mg; Vit. B6, 1250 mg; Vit. B12, 10mg; Nicotinic acid 20000 mg; calcium pantothenate, 500 mg; Folic acid 500 mg; Biotin 50 mg; Iron 22 g; Copper 2.5 g; Zinc 37.5 g; Manganese 31 g; Iodine 650 mg; Selenium 113 mg; cobalt 50 mg.

min. test period, and was carried out according to the methodology proposed by Heiblum *et al.* (1998).

Serum biochemical analyses

Serum biochemical parameters were examined at 9 weeks of age. After 12 h fasting, blood samples were collected in non-heparinized tube from 3 birds in each treatment and the blood was allotted to clot at ambient temperature, centrifuged at 2000 rpm for 15 min to obtain serum. The serum samples were analyzed for total protein, albumin, calcium and phosphorus by spectrophotometer using commercial test kits manufactured by Spectrum Company, Cairo, Egypt.

Carcass characteristics

At the end of the trial, 12 birds (3 per group) were sampled randomly for carcass evaluations, then slaughtered and weighed. Afterward, were scalded, de-feathered and carcasses were eviscerated. The whole carcass, liver (without gallbladder), heart, spleen and empty gizzard were excised and weighed individually. The carcass data and the weights of internal organs are presented based on preslaughter live weight of each broiler chicken.

Economic evaluation

At the end of experiment, the indices of the economic evaluation were calculated according to Hassan and El Shoukary (2019) and Omar *et al*. (2019) per each group of birds (Table 4).

Statistical Analysis

Obtained data were subjected to One-way Anova test by using the SPSS program (version 20). Significant differences among individual means were compared by using Turkey's test at 5% probability.

Results

Growth Performance

The effects of dietary FS supplementations on growth performance parameters are summarized in Table 2. The body weight of birds supplemented with 1.2% FS was significantly ($P<0.05$) higher than broilers in control group on week 7. At the end of the experiment (9 weeks), broilers supplemented with FS had higher body weight ($P<0.05$) in comparison to the control group. Between weeks 5-7, the weight gain of broilers on 1.2% FS was significantly ($P<0.05$) higher than the control group. No significant differences were detected in weight gain of broilers between experimental groups on 7-9 weeks. During the whole period of experiment, the weight gain of broilers in FS groups were significantly ($P<0.05$) higher than control group. Feed intake of broilers did not differ significantly between groups fed on diets supplemented with 0.4 and 0.8 % fennel and fennel free diet on 7 and 9weeks. During the entire period of experiment, 1.2% fennel group was significantly ($P<0.05$) higher than control group. Feed conversion ratio (FCR) did not differ significantly ($P>0.05$) between groups on week's 5-9. At the whole experimental period, the best feed conversion ratio (3.15) was recorded in 1.2% fennel group. No significant differences were detected in EPI and RGR between different experimental groups at 5-7 and 7-9 weeks. During the whole experimental period treatment group of 1.2% FS were numerically higher in EPI (64.14) and RGR (81.75) than other experimental groups.

Behavior and fear responded

The effects of dietary supplementation of different fennel

Table 2. Effects of dietary treatments on growth performance of broilers chicken.

Item	Dietary Treatment					
	Con	FS1	FS2	FS3	SEM	P-value
Body weight (g/bird)						
Initial (5weeks)	433	419	443	439	13.71	0.653
7weeks	649^{b}	707^{ab}	695^{ab}	745^{a}	13.67	0.008
9 weeks	932^{b}	997^{a}	1006^{a}	1047^{a}	11.39	0.001
Bodyweight gain (g/bird)						
5-7 weeks	216^{b}	287^{ab}	252^{ab}	306^{a}	17.4	0.028
7-9 weeks	283	290	312	302	16.52	0.589
Overall	499^{b}	577^{a}	564^{a}	607^{a}	9.85	0.001
Feed intake (g/bird)						
7weeks	732	758	775	800	15.76	0.077
9 weeks	1045^{b}	1092^{ab}	1108^{ab}	1118^{a}	14.97	0.035
Overall	1776^{b}	1850^{ab}	1884^{ab}	1918^{a}	21.27	0.008
Feed conversion ratio (g/g)						
5-7 weeks	3.39	2.64	3.19	2.62	0.23	0.109
7-9 weeks	3.7	3.77	3.62	3.71	0.22	0.965
Overall	3.56	3.21	3.34	3.15	0.09	0.055
European production index						
5-7 weeks	42.57	72.64	56.99	78.28	8.52	0.067
7-9 weeks	51.09	51.61	59.43	54.3	5.82	0.738
Overall	46.73^{b}	60.20^{a}	56.39^{ab}	64.14^{a}	2.54	0.007
Relative growth rate						
5-7 weeks	39.96	51.07	44.42	51.61	3.11	0.082
7-9 weeks	35.77	34.04	36.68	33.69	1.94	0.671
Overall	73.12	81.57	77.98	81.75	2.07	0.057

Con; control group fed basal diet; FS1, group fed basal diet supplemented with 0.4% FS; FS2, group fed basal diet supplemented with 0.8% FS and FS3, group fed basal diet supplemented with 1.2% FS.
Means within the same row with different superscripts are significantly different ($P < 0.05$); SEM, pooled Standard errors of means

levels on the ingestive, comfort and aggressive behaviors of broilers are presented in Figs. (1-3). This illustrated that, higher proportion of birds supplemented with fennel 0.4, 0.8 and 1.2 gm/kg diet were more feeding and drinking behavior compared to control one. Moreover, Fig. (4) showed that, the unsupplemented birds showed significantly longer duration in TI test which indicated that control birds were more fearful compared to treatment groups and FS had significant linear decreasing effect on the duration of tonic immobility.

Carcass characteristics and Serum metabolites

The dressing percentage and the means of relative organ's weights for experimental groups are summarized in Table 3. The eviscerated carcass percentage, dressing percentage and relative weight of gizzard, heart liver and spleen did not show any significant difference (P>0.05) between experimental groups. According to the Table 3, broilers chicken fed diets supplemented with different level of FS had significantly (P<0.05) higher values of serum total protein, globulin and lower values (P<0.05) of albumin and albumin/globulin ratio than chickens on the control diet. The use of different levels of FS in broiler chickens diet did not have a significant effect on serum calcium and phosphorus compared to control treatment.

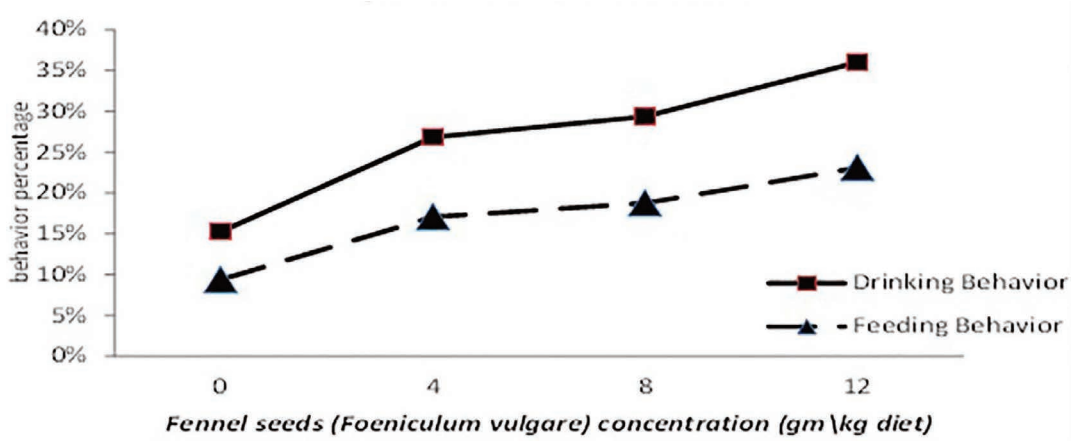

Fig. 1. Effect of different fennel levels on Fayoumi ingestive behavior.

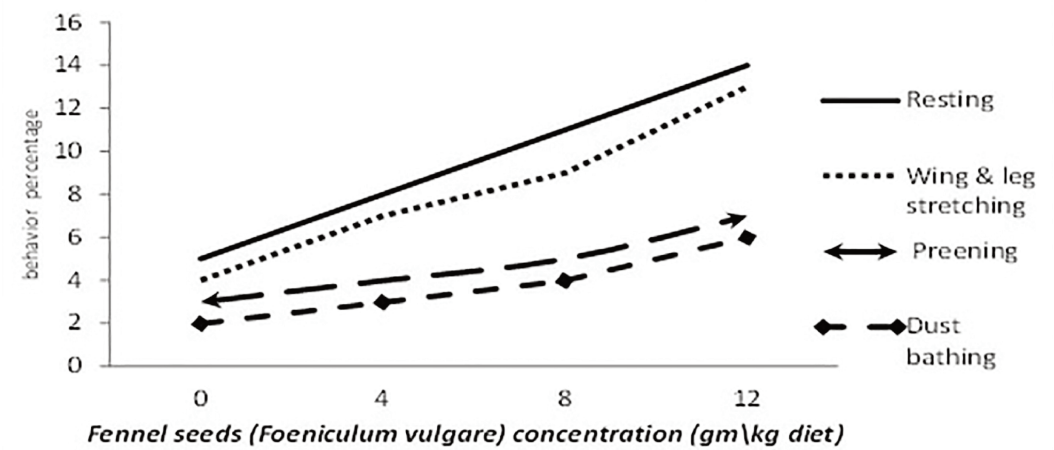

Fig. 2. Effect of different fennel levels on Fayoumi comfort behavior.

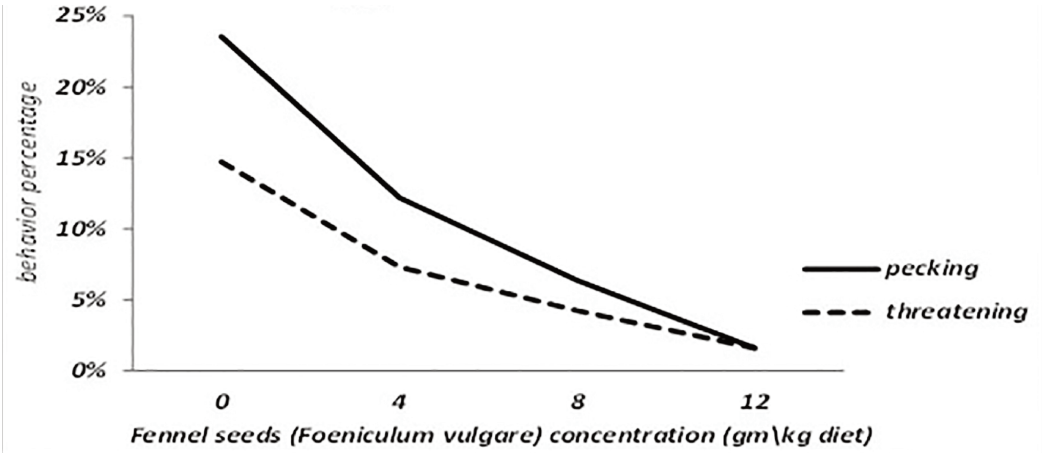

Fig. 3. Effect of different fennel levels on Fayoumi aggressive behavior.

Economic evaluation

The obtained results of economical evaluation of feeding different experimental diets as affected by fennel levels are presented in Table 4. It is obvious that including photogenic feed additives in the dietary treatments increased the feed and production costs as compared to that of the control. It is worthy to note that supplementing 0.4% or 0.8% level of FS to basal diets resulted to reduction in feed cost as compared to corresponding 1.2% level. The highest total and net return (39.79 and 9.25 LE, respectively) were obtained from the sale of meat obtained from broilers fed on diet containing 1.2% FS. The least total and net return were obtained from group fed on control diet (35.42 and 7.09 LE, respectively).

The average economic efficiency values of different treatments were 30.29 % being the best for broilers fed FS at 1.2% level followed by birds fed on diet supplemented with FS at 0.4% level (29.55 %). According to the income-outcome analysis, the highest relative economic feed efficiency was recorded by the birds fed 1.2% FS supplemented diet, followed by birds fed on 0.4 and 0.8 %, respectively.

Discussion

Results obtained showed noticeable improvement in body weight, weight gain, feed intake, feed conversion ratio, European production index and growth rate in comparison with

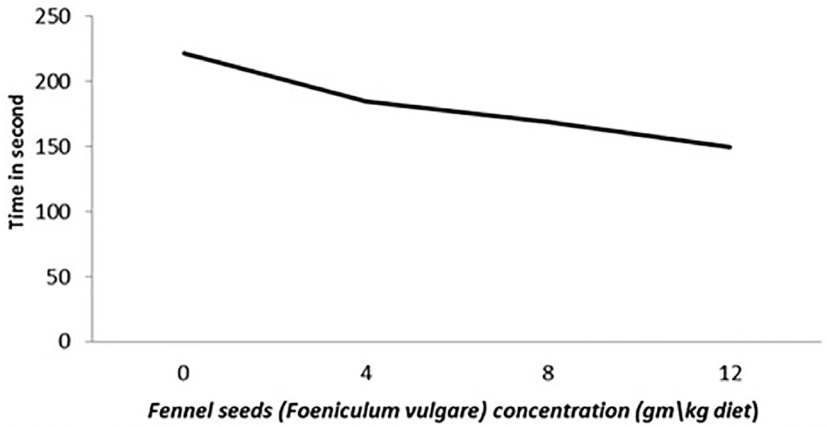

Fig. 4. Effect of different fennel levels on tonic immobility test.

Table 3. Effects of dietary treatments on carcass traits and serum metabolites of broilers chicken.

Item	Dietary Treatment					
	Con	FS1	FS2	FS3	SEM	P-value
Carcass traits (%)						
Eviscerated carcass	68.33	66.67	65.67	68	1.5	0.591
Dressing	73	70.66	70	72.67	1.49	0.449
Gizzard	1.38	1.43	1.62	1.67	0.08	0.083
Heart	0.6	0.49	0.51	0.51	0.05	0.471
Liver	2.3	2.31	2.1	2.31	0.06	0.124
Spleen	0.43	0.42	0.38	0.32	0.03	0.171
Serum metabolites						
Total protein, g/dl	3.24^{b}	4.19^{a}	4.66^{a}	4.51^{a}	0.19	0.03
Albumin, g/dl	1.90^{b}	1.58^{a}	1.89^{a}	1.96^{a}	0.07	0.017
Globulin, g/dl	1.34^{b}	2.61^{a}	2.77^{a}	2.55^{a}	0.22	0.006
Albumin/globulin ratio	1.54^{a}	0.61^{b}	0.68^{b}	0.79^{b}	0.15	0.008
Calcium, mg/dl	9.49	7.76	8.64	8.16	0.57	0.25
Phosphorus, mg/dl	7.79	9.56	8.56	8.7	0.65	0.354

Con; control group fed basal diet; FS1, group fed basal diet supplemented with 0.4% FS; FS2, group fed basal diet supplemented with 0.8% FS and FS3, group fed basal diet supplemented with 1.2% FS. Means within the same row with different superscripts are significantly different ($P < 0.05$).

Table 4. Effect of dietary levels of feed additive on economic efficiency.

Items	Dietary treatment			
	Con	FS1	FS2	FS3
Total feed cost /bird (kg)	13.32	14.25	14.88	15.54
Total production cost (LE)	28.32	29.25	29.88	30.54
Total return (LE)	35.42	37.89	38.23	39.79
Net return (LE)	7.09	8.64	8.34	9.25
Economic efficiency (%)	25.06	29.55	27.92	30.29
Relative economic efficiency	100	118.19	111.69	121.17

Con; control group fed basal diet; FS1, group fed basal diet supplemented with 0.4% FS; FS2, group fed basal diet supplemented with 0.8% FS and FS3, group fed basal diet supplemented with 1.2% FS. LE= Egyptian pound according to price at the experimental time; Total production costs (included the cost of birds, cost of feeding, veterinary care and other husbandry costs); Total return (= the selling price of birds at the end of the experiment); Net return (the difference between the return and cost); Economic efficiency (net return divided by total cost and multiplied by 100); Relative economic efficiency (economic efficiency of group/ economic efficiency of control*100).

control group. These results were in line with those of (Mohammed and Abbas (2009); Hassan and Mukhtar (2015) and Wati *et al.* (2015), who found an increase in body weight, and improvement in feed intake and feed conversion ratio when added fennel to the broilers diet. In contrast, Khalil and Hussein (2020) reported that, the body weight gain, feed intake and production index not affected by the addition of FS to broiler chicken diets. The improvement of body weight of birds fed on fennel supplemented diets might be due to the presence of some active component in essential oils of fennel which enhance the growth of healthier gut microbiota and decrease the production of growth depressing microbiota metabolites as ammonia and amines thus result in increasing the nutrient availability to the host (Murugesan *et al*., 2015; Wati *et al*., 2015). In addition, the phytogenic feed additives improve nutrient absorption by controlling the inflammatory process of the intestinal mucosa and stimulate the secretions of saliva and bile, and enhance the enzyme activaties as trypsin, protease, lipase and amylase (Zhang *et al*., 2013; Gheisar *et al*., 2015). The positive effect of FS on broilers feed intake might be due to the active principals in the seeds as trans-anethole, limonene, estragole and fenchone which are known to have antispasmodic, carminative, estrogenic and appetizing effects (Dhama *et al*., 2015).

In the present study, high proportion of birds supplemented with fennel at concentrations of 0.4, 0.8 and 1.2 g/kg diet had more feeding and drinking behavior compared to control one (Figs 1-3), which agreed with that reported by (Wati *et al*., 2015), and disagree with Khalil and Hussein (2020), The increased feed intake in treatment groups may be due appetite-stimulating effects of fennel ingredients such as anethole and estragole (Cabuk *et al*., 2003), that promote iron absorption, which helps to improve the appetite (EL-Shobaki *et al*., 1990) and prevent gastrointestinal disorders by enhancing the flow of the stomach and intestine digestive juice and increase the efficiency of broken fats to fatty acid (Bown, 2001; El-Deek *et al*. 2003). In addition, fennel seeds contain high levels of nitrites and nitrates which are known to play crucial roles in maintaining vascular and digestive functions (Swaminathan *et al*., 2012). Moreover, nitric oxide plays an important role in regulation of the various physiological functions that are mediated by the hypothalamus such as thermoregulation, fever, and water balance (Dunai and Tzschentke, 2012). The increased in comfort behavior in fennel supplemented groups may be related to the chemical ingredients, which enhance the immune system and reduce the effect of stress and consequently reflected on bird's comfort behavior and welfare. The significant decrease in aggressive behavior in fennel treated groups may be due to the presence of trans-anethole oil which has anti-testosterone properties (Rather *et al*., 2016). The obtained results are in harmony with results of Alexandre *et al*. (2020) and Silva *et al*. (2010).

In the current study, the un-supplemented birds showed significantly longer duration in TI test (Fig. 4), which indicated that control group was more fearful compared to treatment groups, and also that FS had significant linear decreasing effect on the duration of tonic immobility. This finding in agreement with Alexandre *et al*. (2020), who suggesting the use of this herbal medicine as a stress modulating agent. Jones (1986) indicated that a long duration of TIT is thought to be indicative of high levels of fearfulness. Poor productive performance of control birds may be a consequence of fearfulness. Faure *et al*. (2003) indicated a negative correlation between the welfare and performance of birds and fear responses.

In agreement with findings from this study, Khalil and Hussein (2020) reported that the percentages of dressing, gizzard and liver were not significantly different among the tested groups. Also, Hassan and Mukhtar (2015) recorded that addition of fennel seeds to broilers diet did not show any significant effect on gizzard, heart and liver relative weights compared with control group. In accordance with the obtained results, Hassan and Mukhtar (2015) recorded that dietary supplementation of fennel seeds did not affect the level of calcium in the serum of broilers chicken. However, Wati *et al* (2015) observed no effect on serum total protein and albumin between experimental groups by addition of fennel seeds to broiler diets. The positive effect of fennel seeds on bird's immunity which indicated by increasing globulin level might be due to the presence of essential oils that increase lymphocyte proliferation rate, phagocytosis and immunoglobulins secretion such as IgA and IgM in the blood of the birds (Steiner and Syed, 2015).

The differences in economic efficiency parameters among different experimental groups revealed that fennel fortification at 1.2% level had positive impacts on the total return, net revenue, economic efficiency and relative economic efficiency and could be used economical as growth promoters. These improvements could be attributed to the better findings obtained either in growth performance or feed conversion of broilers. These results agree with Kassu *et al*. (2016) who reported that the dietary inclusion levels of herbal feed additives in broiler diets recorded the least cost per kilogram gain and the highest percent of economic efficiency compared with that of the un-fortified diet.

Conclusion

Dietary inclusion of fennel seeds to fayoumi chicken, especially at 1.2%, has a beneficial impact on the behavior, fear response, growth, some serum biochemical parameters, general health status and the economic efficiency of broilers chickens. Furthermore, they can be used as economical natural growth promoter.

Conflict of interest

Author declares no conflict of interests exists.

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