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Research Article
Effects of Terbutaline on Growth Performance, Carcass Quality, Some Biochemical Parameters and its Residues in Broiler Chicken

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Abstract

Background and Objective: Terbutaline is a β-agonist that used as growth promoters to improved carcass chemical composition of chicks without residues. The purpose of the present investigation is exploring the effect of different dietary levels and duration of terbutaline on the productive performance, biochemical and carcass quality traits including residue of acres broiler. **Materials and Methods:** A total of 150 one-day-old arbor acres broiler chicks were allotted into 5 groups (3 replicates per each). Group 1 was fed on the basal diet without supplement, while groups 2-5 fed on the basal diet supplemented by 5 or 10 mg terbutaline kg^{-1} diet during 1-42 or 21-42 days, respectively. **Results:** When handling the dietary levels and duration of terbutaline, results of the present study showed that10 mg terbutaline kg^{-1} diet during the whole experimental period is a more effective dose for improvement of growth performance with significant ($p \leq 0.05$) increased serum protein and breast muscles relative weight compared with control. Also, 10 mg terbutaline kg^{-1} diet during the whole experimental period significantly ($p \leq 0.05$) increase d CP% (crude protein%) and CHO% (carbohydrate%) of breast muscle and significantly ($p \leq 0.05$) decreased fat% (ether extract%) of breast muscle and abdominal fat relative weight compared with control. Meanwhile, 5 mg terbutaline kg^{-1} diet during 1-42 or 21-42 days has no significant effect on the above-mentioned parameters. Regarding residue, the terbutaline residue wasn't detected in broiler meat. **Conclusion:** It can conclude that 10 mg terbutaline kg^{-1} diet during the whole experimental period is a better dose and duration for improving growth performance, the chemical composition of breast muscle and carcass traits of broiler chickens with no terbutaline residue in breast muscle.

Key words: Broilers, β-agonists, terbutaline, growth performance, carcass quality, biochemical parameters

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Since the latter half of the 20th century, prepared chicken has become a staple of fast food. Chicken is sometimes cited as being more healthful than red meat, with lower concentrations of cholesterol and saturated fat[1]. So, the major concern in meat animal production is to produce acceptable meat with high quality as a source of protein for the consumer[2]. Generally, the attempts to increase growth rates of broiler chicks accompanied by excessive fat accumulation in different parts of poultry carcass especially abdominal and visceral areas which is undesired by consumers and represents a waste product in meat processors, consequently, most researchers have been focused on the improvement of animal production efficiency and also production of meat accretion with less fat in carcass[3]. This has been facilitated by the many attempts and discovery of several compounds that exert dramatic effects on carcass composition. The β-adrenergic agonists are used to increase growth and muscle development of farm animals[4]. The function of these compounds is similar to catecholamine[5]. Fat reduction in poultry carcass by β-agonists supplementation may occur through 2 metabolic pathways: reduction in lipogenesis and/or increase in lipolysis[6].

Generally, the growth-promoting effect of β-adrenergic agonists may be related to the type of β-agonist used, the dosage of supplemented material and poultry species as well as the duration of treatment may also be involved, those factors may account for the apparent discrepancies between broilers. In several experiments, terbutaline (a beta-adrenergic agonist) supplementation in broiler chickens' diet 5 and 10 mg kg^{-1}, didn't affect daily weight gain, with the improvement of FCR of male chicks compared with the control group[2]. Other studies on Japanese quails showed that terbutaline increased the relative weights of breast and drumstick muscles, plasma levels of free fatty acids and significantly decreased abdominal fat[7]. Other studies showed that β-agonists increased skeletal muscle mass, protein deposition, carcass yield and decreased carcass fat of broiler chickens[8].

The contamination of veterinary drugs in the environment has been an important issue because their residues could result in the increase of drug resistant-bacteria and antibiotic-resistance infection[9]. Beta-agonist residues produced via improper use could lead to adverse effects, including an increased risk for adverse cardiovascular events[10]. However, all drugs approved for use in food-producing animals have a withdrawal time to prevent residues in food of animal origin that are potentially harmful to consumers[11]. In other words, a residual concentration in tissue must be below a given maximum residue limit (MRL) when the animals are slaughtered and sold on the market[12]. Therefore, this investigation was designed to produce high-quality meat and improve growth performance by dietary inclusion of β-agonist, terbutaline into broiler diet and detection its residues in muscle.

For knowledge, there is much research about the effects of terbutaline on growth performance and biochemical parameters in broiler chickens but the effect of different dosage and duration of terbutaline supplementation on growth performance, biochemical parameters, carcass traits and its residue in broiler chickens very rare addressed previously especially terbutaline residue in the breast muscle. Therefore, the main objective of this study is to through light on the effect of different dose and duration of terbutaline supplementation on carcass quality of broiler chicks with special reference to terbutaline residues in carcass muscles.

MATERIALS AND METHODS

Birds accommodation and management: This investigation was done on 150 one-day-old arbor acre chicks (obtained from a private farm) and reared for 42 days. The chicks were housed in a clean well-ventilated room, previously disinfected with formalin. The environmental temperature of the room was adjusted according to the age of the birds through electric heaters. Feed and water were supplied *ad-libitum*. Prophylactic measures were carried out against the most common infectious diseases. The chicks were vaccinated against Newcastle disease and Infectious Bursal disease.

Experimental design and feeding program: Chicks were randomly allotted into 5 groups, of 30 each (3 replicates/group) and received one out of the different experimental diets during the experimental period (42 days). The treatment diets were formulated[13] to meet the requirements of broiler chickens. The applied experimental design along the life of birds was to give different doses and supplementation period of β-agonist (terbutaline) to the different groups as shown in the Table 1. The different proportions of ingredient to meet the requirements at different production periods and chemical analysis of the experimental diets are presented in the Table 2. Growth performance parameters and feed intake of broiler chicks in different groups were weekly recorded. Feed conversion ratio (FCR) was calculated.

Table 1: Experimental design for both experiments

		Supplementation dose and period			
		Terbutaline (5 mg kg^{-1})		Terbutaline (10 mg kg^{-1})	
Groups	Diet	1-42 days	21-42 days	1-42 days	21-42 days
1	Basal diet	--	--	--	--
2	Basal diet	+	--	--	--
3	Basal diet	--	+	--	--
4	Basal diet	--	--	+	--
5	Basal diet	--	--	--	+

It is a beta-adrenergic agonist made in agrarian marketing corporation company, USA, imported by IFT (International free trade company) for animal health research institute, Egypt

Table 2: Ingredients and calculated chemical composition of the used basal diets

	Ingredients (%)		Chemical composition		
Ingredients	Starter	Grower and finisher	Items	Starter	Grower and finisher
Yellow corn	55.00	61.50	ME (Kcal kg^{-1})	3225.80	3209.30
Soybean (44%)	25.50	25.50	CP (%)	23.09	20.04
Corn gluten meal (62%)	11.22	5.59	Calcium (%)	1.00	0.90
Corn oil	4.00	3.80	AP (%)	0.45	0.35
DCP[1]	1.80	1.25	Lysine (%)	1.10	1.00
Limestone[2]	1.30	1.36	Meth+Cyst (%)	0.90	0.72
Lysine[3]	0.16	0.10			
DL-methionine[4]	0.10	0.03			
Common salt	0.40	0.40			
Choline chloride (60%)[5]	0.22	0.17			
Premix[6]	0.30	0.30			

[1] Di-calcium phosphate (DCP): Contains 18% phosphorus and 25% calcium, [2]Limestone: Contains 37% calcium and locally produced, [3]Lysine: 87% produced by Archer Daniels method company De Caur LL. Made in U. S. A., [4]DL-methionine: Produced by Evoink Co. Guranted analysis 99.5% DL- methionine, [5]Choline chloride: 60% with vegetable carrier (corn powder) produced by Shandyuong Pharmaceutical Co. China, [6]Premix: Each 3.0 kg contains, Vit A (12000000 IU), Vit D (2000000 IU), Vit E (10 g), Vit K3 (2 g), Vit B1 (1g), Vit B2 (5 g), Vit B6 (1.5 g), Vit B12 (10 g), nicotinic acid (30 g), pantothenic acid (10 g), folic acid (1 g), biotin (50 mg), iron (30 g), copper (10 g), zinc (50 g), manganese (60 g), iodine (1 g), selenium (0.1 g), cobalt (0.1 g), carrier Q.S up to 3.0 kg

Chemical analysis of feed and meat: The proximate analysis of feed sample and breast muscle samples (6 samples for the group) for determination of moisture, crude protein (CP), ether extracts (EE), crude fiber (CF), carbohydrate and total ash content were determined[14].

Sampling and biochemical parameters measurements: The blood samples were collected from 6 birds of each group (2 birds from each replicate) after slaughtering at 42 days from the beginning of 2 experiments. After coagulation of the blood samples at room temperature, the serum was separated by centrifugation of coagulated blood at 3000 rpm for 15 min. The clear serum was kept at -20°C until use to detect the serum total cholesterol, low-density lipoprotein (LDL), high-density lipoprotein (HDL), triglycerides, total protein, glucose and uric acid were estimated using commercial kits produced by Bio-Diagnostic (Diagnostic and Research Reagents).

Terbutaline residue in muscle: At the end of this experiment (42nd day of age), muscle samples were collected from 6 birds of each group (2 birds from each replicate) and stored in a deep freezer until use. The terbutaline residue in muscle samples was done[15] where 1 g of muscle was minced with a homogenizer (Yellow Line Model DI 18, IKA, Germany) and 200 mL of pure water and 20 mL of a surrogate solution (clenbuterol-d 9, 0.5 mg L^{-1}) were added to the solution, which was then vortexed for 1 min. After that, the solution was left alone for 10 min and 5 mL of acetonitrile was added. The solution was then left alone again for 15 min to extract β-agonists. After that, the solution was centrifuged at 4000 rpm for 10 min and the supernatant was transferred into a test tube. This extraction and separation processes were repeated twice. The supernatant was evaporated using nitrogen gas and 10 mL of phosphate buffer (pH 5.2 adjusted by hydrochloric acid) and 25 mL of β-glucuronidase from helix pomatia type HP-2 were added and the resulting solution was incubated in a 38°C water bath overnight for hydrolysis. Subsequently, the solution was cooled down to room temperature and the pH was adjusted to 10.5 with sodium hydroxide. These optimal pH adjustments were obtained during the method development to fulfill an acceptable recovery in the LC-MS/MS analysis.

European production efficiency factor (EPEF) calculation: EPEF was calculated[16] as the following:

$$A = \frac{\text{Average live weight (kg)} \times \text{Total live weight sold (kg)}}{\text{Number of broiler chicks started}}$$

$$B = \frac{\text{Average age (days)} \times \text{Total feed used (kg)}}{\text{Number of birds sold}}$$

$$EPEF = \frac{A}{B} \times 10000$$

Statistical analysis: The data obtained were statistically analyzed by one-way ANOVA to study the effect of different treatments on the studied variables using the statistical analysis system[17] at $p \geq 0.05$.

RESULTS

Growth performance: Effect of terbutaline doses and periods of supplementation on broiler chicks growth performance were shown in Table 3. It was observed that β-agonist terbutaline supplementation in broiler chicks' diet at 10 mg kg^{-1} during the whole experimental period (1-42 days) insignificantly ($p \geq 0.05$) increased final weight and total body gain when compared with other groups. Moreover, both doses (5 or 10 mg kg^{-1}) and time of terbutaline supplementation reduced total feed intake and insignificantly ($p \geq 0.05$) improved FCR when compared with control.

Serum biochemical parameters and lipid profile: Table 4 shows that terbutaline supplementation at both doses (5 or 10 mg kg^{-1} diet) and periods significantly ($p<0.05$) increased serum total protein concentration compared with control. On the other hand, terbutaline supplementation at both doses and periods had no significant effect on serum glucose and uric acid concentrations compared with control. There were no significant ($p \geq 0.05$) effects between different treatments in serum triglycerides, total cholesterol, HDL, LDL and VLDL concentrations.

Chemical analysis of meat: Table 5 shows that supplementation of 10 mg of terbutaline kg^{-1} diet during whole period (1-42 days) significantly ($p<0.05$) increased

Table 3: Effect of dietary terbutaline dose and periods of supplementation on growth performance and feed efficiency parameters of broiler chicks

	Terbutaline doses (mg kg^{-1} diet) and periods of supplementation				
		5 mg kg^{-1}		10 mg kg^{-1}	
Items	Control	1-42 days	21-42 days	1-42 days	21-42 days
Body weight development (g/chick)					
Initial weight	41.70±0.95[a]	41.50±0.84[a]	41.43±0.94[a]	42.21±1.05[a]	41.74±0.99[a]
Weight at 3rd week	886.25±26.04[a]	897.89±9.25[a]	856.11±27.69[a]	914.50±42.42[a]	886.11±21.73[a]
Weight at 6th week	1852.14±45.27[a]	1872.78±7.33[a]	1862.22±43.09[a]	1950.50±65.64[a]	1834.44±35.57[a]
Weight gain (g/chick)					
0-3 weeks	845.88±25.36[a]	857.00±8.55[a]	815.44±26.98[a]	872.30±41.59[a]	845.11±20.94[a]
3-6 weeks	992.14±26.97[a]	974.88±3.05[a]	1006.11±24.55[a]	1036.00±36.74[a]	948.33±18.38[a]
Total gain (6-0)	1812.43±44.67[a]	1831.89±6.64[a]	1821.56±42.40[a]	1908.30±64.62[a]	1793.44±34.74[a]
Feed intake (FI) and feed conversion ratio (FCR)					
Total FI (g/chick)	3709.50±00.00	3606.60±0.00	3558.80±00.00	3608.60±00.00	3581.20±00.00
Average FCR	2.04±0.050[a]	1.97±0.01[a]	1.98±0.050[a]	1.89±0.080[a]	2.00±0.040[a]

Values are means±standard error, means within the same row of different letters are significantly different at $p \leq 0.05$

Table 4: Effect of dietary terbutaline dose and periods of supplementation on some serum biochemical units and lipid profile of broiler chicks

	Terbutaline doses (mg kg^{-1} diet) and periods of supplementation				
		5 mg kg^{-1}		10 mg kg^{-1}	
Items	Control	1-42 days	21-42 days	1-42 days	21-42 days
Total protein (g dL^{-1})	6.16±0.12[b]	6.39±0.07[a]	6.40±0.06[a]	6.30±0.08[a]	6.32±0.11[a]
Glucose (mg dL^{-1})	239.73±22.94[a]	222.13±4.24[a]	238.07±15.29[a]	230.80±7.23[a]	224.14±7.06[a]
Uric acid (mg dL^{-1})	5.92±0.02[a]	5.95±0.02[a]	5.97±0.03[a]	5.94±0.04[a]	5.92±0.03[a]
Triglycerides (mg dL^{-1})	199.20±0.95[a]	199.07±2.05[a]	197.87±2.63[a]	197.90±1.42[a]	199.10±2.62[a]
Total cholesterol (mg dL^{-1})	201.93±3.64[a]	199.23±1.50[a]	199.17±0.77[a]	200.67±0.23[a]	200.63±0.82[a]
HDL (mg dL^{-1})	119.53±1.48[a]	118.43±1.44[a]	115.43±3.70[a]	118.60±1.13[a]	119.90±0.71[a]
LDL (mg dL^{-1})	49.20±3.31[a]	47.62±0.62[a]	50.76±2.88[a]	49.08±0.98[a]	47.22±0.64[a]
VLDL (mg dL^{-1})	33.20±0.16[a]	33.18±0.32[a]	32.98±0.44[a]	32.98±0.24[a]	35.52±0.42[a]

Values are means±standard error, means within the same row of different letters are significantly different at $p \leq 0.05$

Table 5: Effect of dietary terbutaline dose and periods of supplementation on breast muscle chemical composition of broiler chicks

	Terbutaline doses (mg kg^{-1} diet) and periods of supplementation				
		5 mg kg^{-1}		10 mg kg^{-1}	
Items (%)	Control	1-42 days	21-42 days	1-42 days	21-42 days
Moisture	74.82±2.60^{a}	73.14±0.98^{ab}	72.88±1.72^{b}	71.81±0.44^{b}	74.53±1.66^{a}
Crude protein	20.27±1.73^{b}	21.76±0.13^{b}	21.62±1.33^{b}	23.25±0.63^{a}	21.39±1.68^{b}
Ether extract	2.75±0.39^{a}	2.25±0.04^{b}	2.32±0.07^{b}	2.34±0.20^{b}	2.25±0.21^{b}
Ash	1.02±0.15^{ab}	0.80±0.30^{b}	1.26±0.06^{a}	0.85±0.23^{b}	0.72±0.08^{b}
Carbohydrates	1.14±0.22^{b}	2.05±0.41^{a}	1.92±0.08^{a}	1.75±0.33^{a}	1.11±0.09^{b}

Values are means±standard error, means within the same row of different letters are significantly different at $p \leq 0.05$

Table 6: Effect of dietary terbutaline dose and periods of supplementation on some carcass traits of broiler chicks as percent of live body weight

	Terbutaline doses (mg kg^{-1} diet) and periods of supplementation				
		5 mg kg^{-1}		10 mg kg^{-1}	
Items (%)	Control	1-42 days	21-42 days	1-42 days	21-42 days
Dressing	72.89±4.36^{a}	76.28±3.68^{a}	75.50±1.14^{a}	76.18±1.97^{a}	76.00±0.97^{a}
Breast muscle	18.52±0.67^{b}	20.01±0.89^{a}	19.21±0.78^{ab}	20.07±0.69^{a}	19.71±1.02^{ab}
Leg muscle	15.43±1.03^{a}	16.16±1.23^{a}	16.21±1.09^{a}	16.70±1.89^{a}	16.09±0.98^{a}
Head	2.37±0.20^{a}	2.35±0.18^{a}	2.32±0.15^{a}	2.33±0.12^{a}	2.39±0.16^{a}
Liver	2.42±0.08^{a}	2.41±0.07^{a}	2.46±0.09^{a}	2.46±0.05^{a}	2.48±0.06^{a}
Heart	0.39±0.02^{a}	0.37±0.01^{a}	0.41±0.01^{a}	0.38±0.01^{a}	0.39±0.01^{a}
Gizzard	1.18±0.02^{c}	1.22±0.04^{b}	1.24±0.02^{ab}	1.32±0.08^{a}	1.27±0.06^{ab}
Abdominal fat	1.94±0.09^{a}	1.19±0.06^{b}	1.22±0.09^{b}	0.90±0.06^{b}	1.10±0.05^{b}

Values are means±standard error, means within the same row of different letters are significantly different at $p \leq 0.05$

Table 7: Effect of dietary terbutaline dose and periods of supplementation on European production efficiency factor (EPEF) of broiler chicks

	Terbutaline doses (mg kg^{-1} diet) and periods of supplementation				
		5 mg kg^{-1}		10 mg kg^{-1}	
Items (%)	Control	1-42 days	21-42 days	1-42 days	21-42 days
Number of started chicks	30.000	30.000	30.000	30.00	30.00
Number of sold birds	27.000	29.000	29.000	30.00	29.00
Final body wt (kg/bird)	1.852	1.872	1.862	1.95	1.834
Total feed intake (kg/bird)	3.710	3.610	3.560	3.61	3.58
EPEF	194.940	222.930	224.170	248.85	216.15
EPEF relative to control	100.000	114.360	114.990	127.70	110.88

breast muscle protein and carbohydrate contents compared with control, while 5 mg kg^{-1} during both starter and finisher periods and supplementation of 10 mg of terbutaline kg^{-1} diet at finisher period non significantly ($p \geq 0.05$) increased breast muscle protein content compared with control. Moreover, it was found that terbutaline supplementation at both doses and periods significantly ($p < 0.05$) reduced breast muscle ether extract content compared with control. On the other hand, terbutaline supplementation at both doses and periods had no clear effect on meat ash content.

Carcass traits: Table 6 shows the effect of terbutaline dose and periods of supplementation on carcass traits. Broiler chicks fed on the basal diet supplemented by 5 or 10 mg terbutaline kg^{-1} during 1-42 or 21-42 days non-significantly ($p \geq 0.05$) increased dressing% and leg muscle relative weight compared with the control group but supplementation of 10 mg terbutaline kg^{-1} during 1-42 days significantly ($p \geq 0.05$) increased breast muscle relative weight compared with the control. Moreover, terbutaline supplementation had no significant effect on head, liver and heart relative weight, while significantly ($p \geq 0.05$) reduced abdominal fat relative weight compared with control.

Production efficiency study of the experiment: Table 7 shows that terbutaline supplementation at different doses and time improved EPEF of broiler chicks compared to control. The highest EPEF value was obtained by broiler chicken group fed on the basal diet with terbutaline 10 mg kg^{-1} diet during the whole experimental period (248.85), followed by of broiler chicks compared to control. The highest EPEF value was obtained by broiler chicken group fed on the basal diet with terbutaline 5 mg kg^{-1} diet during the whole experimental period (222.93), while the lowest EPEF was obtained by

broiler chicken fed on the basal diet without supplementation (194.94).

Terbutaline residue in muscle: Figure 1-4 shows the concentration of β-agonist terbutaline in broiler chicks breast muscle samples collected at the end of both experiments. No terbutaline was detected (zero levels) in broiler chicks meat fed on a basal diet without supplementation or supplemented by terbutaline at both doses (5 or 10 mg kg^{-1} diet) and different periods.

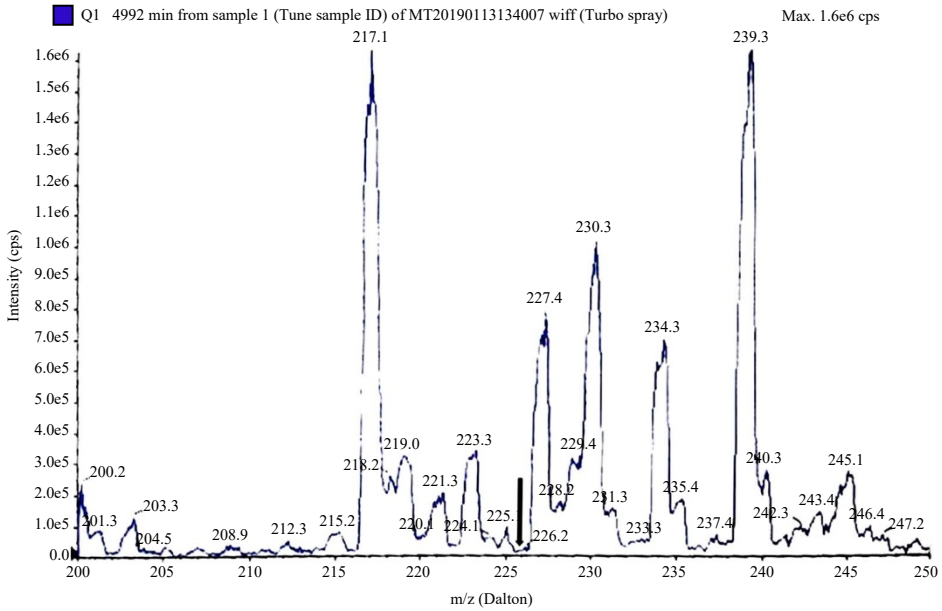

Fig. 1: Concentration of beta-agonists terbutaline (arrow at its molecular weight "225.29") residue in breast muscle of broiler chicks group fed on diet supplemented by 5 mg terbutaline during whole period

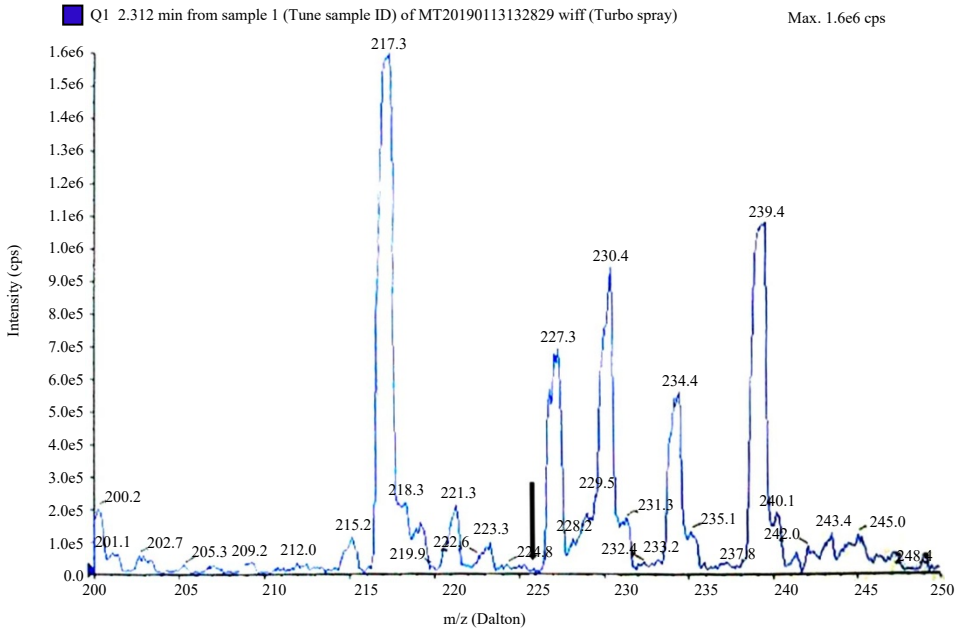

Fig. 2: Concentration of beta-agonists terbutaline (arrow at its molecular weight "225.29") residue in breast muscle of broiler chicks group fed on diet supplemented by 5 mg terbutaline during 21-42 day

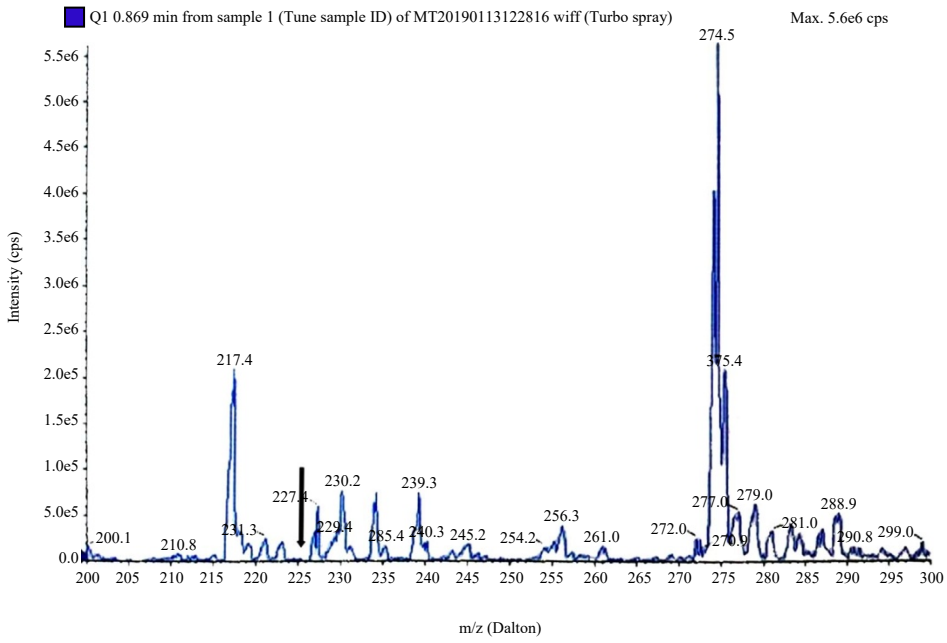

Fig. 3: Concentration of beta-agonists terbutaline (arrow at its molecular weight "225.29") residue in breast muscle of broiler chicks group fed on diet supplemented by 10 mg terbutaline during whole period

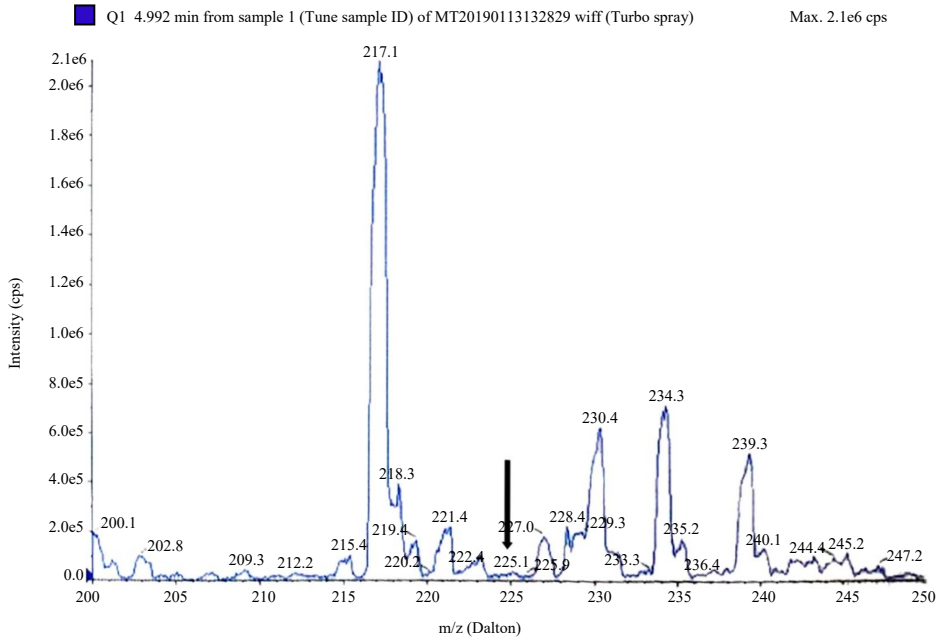

Fig. 4: Concentration of beta-agonists terbutaline (arrow at its molecular weight "225.29") residue in breast muscle of broiler chicks group fed on diet supplemented by 10 mg terbutaline during 21-42 day

DISCUSSION

The improvement of growth performance with terbutaline supplementation associated with decreased feed intake may be due to terbutaline doses and duration, bird maturity and hormonal changes, β-agonists receptor in the target tissues may be rapidly inactivated or a particular species might have a limited number of β-agonists receptors in the target tissues, reducing the response to the agonist. Perhaps the broiler chick is one of the species that has a limited

number of receptors. These results are in harmony with the reports by Yousefi *et al.*[18] and Kor *et al.*[19] with terbutaline and Ortiz *et al.*[20] with clenbuterol in broilers but are not consistent with the results of Fawcett *et al.*[21]. Also, Ansari-Pirsaraei[5] demonstrated that terbutaline did not affect daily weight gain but reduced feed conversion ratio (FCR) of male broilers when 5 and 10 mg kg^{-1} were fed, respectively. Also, Shahneh *et al.*[22] stated that feed intake was lowest in females quail chicks fed Salbutamol 7 mg kg^{-1} diet compared with other Salbutamol dose or control group. Mohammadi-Arekhlo *et al.*[23] reported that zilpaterol supplementation in the diet of male Japanese improved growth performance during the finishing period (34-40 days). This improvement in growth performance parameter was associated without adverse effect on biochemical parameters. Results of biochemical parameters may be attributed to the pharmacodynamic properties of the drug. Fallah *et al.*[4] reported that the pharmacodynamic properties of a particular β-agonist administrated to a particular species are expected to be influenced by genetic, sex and age-borne variations in drug metabolism and delivery systems. The present data are supported by Boostan *et al.*[7], who reported that terbutaline supplementation had a minimal effect on plasma glucose, cholesterol and triglyceride levels of Japanese quail. But opposed to those found by Kor *et al.*[19] and Ansari-Pirsaraei *et al.*[5]. Also, Abolghasemi *et al.*[2] reported an increase in the plasma level of cholesterol, triglyceride and glucose in chicks receiving Terbutaline. Responses to various β-AA vary with age, species, sex, diet, breed, dose and duration of treatment, which may be due to stimulation of different receptors[24]. Beta-agonists have generally decreased the fat content of the meat but their effects on protein content have been dependent on the species, duration of treatment and also the type of β-agonists[8]. The protein content of broiler chicks' breast muscle was higher in the highest terbutaline dosage and more time (10 mg kg^{-1} diet during the whole experimental period). These results in harmony with results of Boostan *et al.*[7], who reported that dietary terbutaline had a positive effect on carcass composition. Chemical composition of the combination of breast and leg muscles were not affected by zilpaterol supplementation in the diet of male Japanese quail[23]. The improvement of carcass traits especially breast muscle and abdominal fat supported by results of Pirsaraei *et al.*[25], who reported that terbutaline significantly increased the ratio of the breast to live weight of female chicks. These data also are in harmony with those obtained by Ortiz *et al.*[20], who indicated that from day 20 until the last of the experimental period (56-day-old), the efficacy of clenbuterol was evident to increase growth and decrease abdominal fat deposition rates ($p<0.01$), in a dose-response pattern. On the other hand, Asadi *et al.*[26], reported ractopamine doesn't affect carcass traits of broiler chicks. The wide variety of these compounds and their extensive use in farm animals give rise to enormous challenges of daily supervision and routine monitoring for the government. So, it is necessary to develop a validated method with characteristics of high sensitivity for the detection and quantification of β-adrenergic agonists drugs in food stuffs[27,28]. To ensure the safety and hygiene of meat regulatory laws have been established for veterinary drugs used in food-producing animals, which allow regular monitoring for residual veterinary drugs in livestock products. Consumption of animal tissues with high β-adrenergic agonist content by humans leads to symptoms such as muscle tremor, muscle pain, nausea and dizziness and can make a serious threat to life[29]. So, it is very important to make monitoring the residue of such drugs.

Socio-economic impact because of the consumers' growing demands for high-quality protein without residue, where poultry meat more healthful than red meat with lower concentrations of cholesterol and saturated fat, so the poultry industry focused on intensive fattening. Results in the present study might have some economic benefits. From the aforementioned discussion, using terbutaline might overcome this economic requirement since it improved growth performance and increased crude protein and relative weight of the breast muscle. Consequently, it can positively affect human health.

CONCLUSION

The obtained data of the present study revealed that β-agonist terbutaline affected growth performance, breast muscle chemical composition and carcass traits of broiler chickens with no terbutaline residue in breast muscle. Moreover, it can be concluded that 10 mg terbutaline kg^{-1} diet during the whole experimental period is a more effective dose for improving growth performance, feed efficiency, reducing abdominal fat and increase muscle protein content without any adverse effect on biochemical parameters.

SIGNIFICANCE STATEMENT

This study discovered the 10 mg terbutaline kg^{-1} diet during the whole experimental period is a better dose and duration that can be beneficial for improving growth performance, the chemical composition of breast muscle and carcass traits of broiler chickens with no terbutaline residue in breast muscle. So, this study will help the researchers to

uncover the critical areas of carcass quality including residue that many researchers were not able to explore. Thus, a new theory on carcass quality including residue may be arrived at.

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REFERENCES

1. FAO., IFAD, UNICEF, WFP. and WHO., 2017. The State of Food Security and Nutrition in the World 2017: Building Resilience for Peace and Food Security. Food and Agriculture Organization of the United Nations, Rome, ISBN: 978-92-5-109888-2, Pages: 132.
2. Abolghasemi, S.A.H., A.R. Jafari-Sayadi, S.M.A. Jalali-Hajiabadi and Z. Ansari-Pirsaraei, 2007. The effects of a beta adrenergic agonist on performance of broiler chicks. J. Sci. Technol. Agric. Nat. Resourc., 10: 471-480, (In Persian).
3. Mohammadi, M., M. Abazari and M. Nourozi, 2006. Effects of two beta-adrenergic agonists on adipose tissue, plasma hormones and metabolites of Moghani ewes. Small Rum. Res., 63: 84-90.
4. Fallah, R., P. Nazari and E. Mirzaei, 2016. Effect of different levels of terbutaline and L-carnitine on the growth performance, carcass traits, blood parameters and immune system of broiler chickens. Malaysian J. Anim. Sci., 19: 57-69.
5. Ansari-Pirsaraei, Z., A.H. Abolghasemi, A.R. Jafari-Sayadi and M.A. Jalali-Hajiabadi, 2007. Effect of terbutaline feeding on some blood parameters and carcass characteristics in broiler chicks. Proceedings of the 16th European Symposium on Poultry Nutrition, August 26-30, 2007, Strasbourg, France, pp: 483-486.
6. Ferreira, M.S.D.S., C.A.P. Garbossa, G. Oberlender, L.J. Pereira, M.G. Zangeronimo, R.V.D. Sousa and V.D.S. Cantarelli, 2013. Effect of ractopamine on lipid metabolism *in vivo*-a systematic review. Braz. Arch. Biol. Technol., 56: 35-43.
7. Boostan, M.J., A.Z. Shahneh, M. Shivazad and A. Akhlaghi, 2015. Effects of dietary beta-adrenergic agonist, terbutaline, on carcass characteristics and blood attributes in Japanese quails (*Coturnix coturnix* Japonica). Poult. Sci. J., 3: 17-25.
8. Shahneh, A.A., R. Mataji, M.J. Zamiri and M.M. Shahr-e-Babak, 2001. Effects of β-Adrenergic agonist metaproterenol on carcass quality and quantity of Varamini female lambs. J. Sci. Technol. Agric. Nat. Resour., 5: 157-166, (In Persian).
9. Lombardo-Agüí, M., A.M. García-Campaña, C. Cruces-Blanco and L. Gámiz-Gracia, 2015. Determination of quinolones in fish by ultra-high performance liquid chromatography with fluorescence detection using QuEChERS as sample treatment. Food Control, 50: 864-868.
10. Salpeter, S.R., T.M. Ormiston and E.E. Salpeter, 2004. Cardiovascular effects of β-agonists in patients with asthma and COPD: A meta-analysis. Chest, 125: 2309-2321.
11. Gehring, R., R.E. Baynes, J. Wang, A.L. Craigmill and J.E. Riviere, 2004. A web-based decision support system to estimate extended withdrawal intervals. Comput. Electron. Agric., 44: 145-151.
12. Damte, D., H.J. Jeong, S.J. Lee, B.H. Cho, J.C. Kim and S.C. Park, 2012. Evaluation of linear regression statistical approaches for withdrawal time estimation of veterinary drugs. Food Chem. Toxicol., 50: 773-778.
13. NRC., 1994. Nutrient Requirements of Poultry. 9th Edn., National Academy Press, Washington, DC., USA., ISBN-13: 9780309048927, Pages: 155.
14. AOAC., 1980. Official Methods of Analysis. 13th Edn., Association of Official Analytical Chemists, Washington, D.C.
15. Sakai, N., R.M. Yusof, M. Sapar, M. Yoneda and M.A. Mohd, 2016. Spatial analysis and source profiling of beta-agonists and sulfonamides in Langat River basin, Malaysia. Sci. Total Environ., 548: 43-50.
16. Sainsbury, D., 1984. Systems of Management. In: Poultry Health and Management, Sainsbury, D. (Ed.). 2nd Edn., Granada Publishing Ltd., London, pp: 102-104.
17. SAS., 2004. SAS/ETS 9.1 User's Guide. SAS Institute Inc., Cary, NC, USA., ISBN: 1-59047-244-6, Pages: 2416.
18. Yousefi, J., N. Maheri-Sis, A. Shaddel-Telli, K. Hatefinezhad, B. Eshartkhah and S.N. Saber, 2011. Effect of salbutamol (A beta-adrenergic agonist) on growth performance of broiler chickens. Ann. Biol. Res., 2: 500-505.
19. Kor, N.M., R. Farhadi and P. Rousta, 2013. The effects of different levels B-adrenergic agonist (Ractopamine) on performance and some blood parameters in broiler chickens. Eur. J. Exp. Biol., 3: 258-261.
20. Ortiz, M.R., F.A. Valdivia, R.J. Martínez and A.A. de Martínez, 2000. Effect of clenbuterol on growth performance in broilers. Arq. Bras. Med. Vet. Zootec., 52: 256-260.
21. Fawcett, J.P., V. Ravindran, P.C.H. Morel, M. Zhang, V.B. Ciofalo, C.B. Spainhour and G. Aberg, 2004. Influence of salbutamol administered as the single active enantiomer (R-salbutamol) on the growth performance and carcass characteristics of broiler chickens. Anim. Sci., 78: 23-30.
22. Shahneh, A.Z., H.A.B. Nejhad, E. Rowghani, B. Eilami and S. Rowghani, 2012. Effects of salbutamol on growth performance and carcass characteristics of Japanese quail (*Coturnix japonica*). Iran. J. Vet. Res., 13: 112-119.

23. Mohammadi-Arekhlo, M., A. Towhidi, H. Moravej and M. Sharafi, 2015. Effect of different zilpaterol hydrochloride levels and feeding methods on the growth performance, carcass traits and blood parameters of male Japanese quails during two weeks of the finishing period. Braz. J. Poult. Sci., 17: 567-574.
24. Beermann, D.H., 2002. Beta-Adrenergic receptor agonist modulation of skeletal muscle growth. J. Anim. Sci., 80: E18-E23.
25. Pirsaraei, Z.A., A. Abolghasemi, A.J. Sayadi and M. Jalali, 2006. Effects of a beta-adrenergic agonist, Terbutaline, on carcass characteristics and performance of Cobb broiler chicks. Proceedings of the EPC 2006-12th European Poultry Conference, Verona, Italy, September 10-14, 2006, World's Poultry Science Association (WPSA).
26. Asadi, H., A.A. Sadeghi, N. Eila and M. Aminafshar, 2016. Carcass traits and immune response of broiler chickens fed dietary L-carnitine, coenzyme Q_{10} and ractopamine. Braz. J. Poult. Sci., 18: 677-682.
27. Beucher, L., G. Dervilly-Pinel, S. Pre'vost, F. Monteau and B. Le Bizec, 2015. Determination of a large set of β-adrenergic agonists in animal matrices based on ion mobility and mass separations. Anal. Chem., 87: 9234-9242.
28. Zhang, Z., H. Yan, F. Cui, H. Yun and X. Chang *et al*., 2016. Analysis of multiple β-agonist and β-blocker residues in porcine muscle using improved QuEChERS method and UHPLC-LTQ orbitrap mass spectrometry. Food Anal. Methods, 9: 915-924.
29. Brambilla, G., T. Cenci, F. Franconi, R. Galarini and A. Macrı *et al*., 2000. Clinical and pharmacological profile in a clenbuterol epidemic poisoning of contaminated beef meat in Italy. Toxicol. Lett., 114: 47-53.