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Effects of Salbutamol on growth performance and carcass characteristics of Japanese quail (Coturnix japonica)

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Summary

The effects of feeding diets containing Salbutamol (0, 1, 3, 5 and 7 mg/kg diet) from 21 to 49 days of age on growth performance and carcass characteristics in 180 male and 180 female Japanese quails (Coturnix japonica) were studied using a factorial arrangement based on completely randomized design. Gender had significant effect on weight gain ($P<0.05$). Salbutamol in the diets increased weight gains but the differences were not statistically significant ($P>0.05$). Salbutamol increased ($P<0.05$) weight gains in both sexes, but the magnitude of increasing was greater in females. Weight gain in males and females receiving the diet containing 7 mg Salbutamol/kg increased by 13 and 10 g, respectively compared to the control groups. Food intake was affected by Salbutamol and was higher ($P<0.01$) in female than male quails. Diets containing Salbutamol increased food intake in male and decreased in female quails ($P<0.01$) compared with the control groups. Food intake was lowest in females fed 7 mg Salbutamol/kg diet. The food conversion ratio (FCR) was lower (better) ($P<0.05$) in females than in males. FCR were improved ($P>0.05$) by Salbutamol administration. Gender affected leg weight ($P<0.05$), breast weight, relative weight of leg and liver weight ($P<0.01$). The breast weight, leg weight and liver weight were significantly higher in females than males but relative weight of leg was significantly lower ($P<0.01$) in females. The breast weight, relative weight of breast and relative weight of leg were significantly affected by Salbutamol. Gender, Salbutamol and their interactions did not affect the chemical composition of breast muscle. The results of the experiment demonstrated that, Salbutamol had beneficial effects on growth performance and carcass characteristics and it seems that feeding 7 mg Salbutamol/kg diet was more effective in female than male Japanese quails.

Key words: Salbutamol, Weight gain, Carcass characteristics, Japanese quail

Introduction

In recent years, the interest of most researchers has been focused on the improvement of animal production efficiency and also production of meat accretion with less fat in carcass (Mohammadi *et al*., 2006). This has been facilitated by the discovery of several compounds that exert dramatic effects on carcass composition. As an example, synthetic β-adrenergic agonists (β-agonists) which are structurally and functionally similar to the endogenous Catecholamines could be mentioned (Beerman, 1993; Malucelli *et al*., 1994; Mersmann, 1998). They elicit their biological responses by binding to β-adrenergic receptors in target cells (Etherton and Smith, 1991). Catecholamines, especially Epinephrine, stimulate carbohydrate metabolism causing quick changes in serum carbohydrate level that provide an immediate energy source for "fight or flight" response. Also, they facilitate the regulation of growth and may improve growth performance (Etherton and

Smith, 1991; Avendano-Reyes *et al*., 2006). Muscular hypertrophy is one of the most consistent effects observed after the administration of β-agonists. This may be related to an increase in Satellite cells proliferation, stimulation of myofibrillar protein synthesis and a decrease in myofibrillar protein degradation (Etherton and Smith, 1991). There is evidence that β-agonists can induce muscular hypertrophy by a direct effect on transcription of genes encoding myofibrillar proteins (Etherton and Smith, 1991; Malucelli *et al*., 1994). β-agonists in particular, increase the degradation of adipocytes and adipocytes metabolism (Mersmann, 2002). The degradation of triacyglycerol, in the adipose tissues, is initiated by hormone-sensitive lipase following activation of the β-adrenergic receptors (Mersmann, 1998). Phosphorylated lipase is the activated form that initiates the degradative lipolysis process (Mersmann, 1987). Other studies show that β-agonists may increase skeletal muscle mass, protein deposition, carcass yield and decrease carcass fat (Malucelli *et al*., 1994; Zare Shahneh *et al*., 2001). The positive effects of β-agonists on performance and repartitioning in meat producing animals, including poultry, have been documented (NRC, 1990; Wellenreiter, 1991; Smith, 1998). The positive effects of β-agonists were more pronounced in sheep and cows, which is in contrast to birds and pigs having low and intermediate activity, respectively (Gwartney *et al*., 1991). Although the responses vary according to the species, the type of β-agonist which is used and duration of treatment may also be involved (Fennessy *et al*., 1990; Zare Shahneh *et al*., 2001). Grant *et al*. (1990) have recently shown that cell culture of chicken skeletal muscle, when exposed to Isoproterenol proliferate more rapidly. Forsberg and Merrill (1986) have shown that Cimaterol decreases protein degradation in rat myoblasts. Miller *et al*. (1988) demonstrated that lipogenic enzyme activities (Fatty acid synthetase, NADP-malic dehydrogenase, 6-phosphogluconate dehydrogenase and glucose-6-phosphate dehydrogenase) were depressed (P<0.05) in subcutaneous adipose tissue samples from Clenbuterol-treated heifers. Fawcett *et al*. (2004) reported that chickens receiving diet containing R-salbutamol had less abdominal and carcass fat. The decrease in carcass fat may be due to inhibition of lipid synthesis, while the reduction in the relative weight of abdominal fat may suggest lipolytic activity (Fawcett *et al*., 2004).

The objective of this study was to investigate the effect of Salbutamol on growth performance and carcass characteristics of Japanese quail.

Materials and Methods

Quails and dietary treatments

Four hundred Japanese quails were purchased from a local commercial producer and were housed in a temperature-controlled room with continuous lighting and were fed with a commercial diet up to 20 days of age. Sexing was performed according to the differences in breast feather color on day 18, and 180 birds from each sex were kept for the experiment. The average body weights (±SD) of male and female quail were 86.6 ± 3.4 and 87.0 ± 3.6 g, respectively. Birds from each sex were allocated in partitioned-battery units with 5 treatments and 3 replicates for each treatment (12 birds per replicate and 36 birds per each ten treatments).

The experiment was conducted at the Research Farm, Islamic Azad University, Darab Branch. A maize-soya bean meal diet that was formulated to meet or exceed NRC (1994) recommendation for quail was served as a control diet (CP=24%; ME=3000 kcal/kg, Table 1). Salbutamol (was purchased from Daroupakhsh Pharma-ceutical Co., Tehran, Iran) was added to the basal diet at levels of 0, 1, 3, 5 and 7 (mg/kg of diet). Diets containing salbutamol were fed (*ad libitum*) to birds from 21 to 49 days of age. Body weight and pen feed intake were recorded at weekly intervals and food conversion ratio (FCR) was calculated. At 49 days of age, the study was terminated and 90 quails (3 quails per replicate) were randomly selected after 3 h deprivation of food, weighed, and slaughtered to determine the carcass composition. After careful dissection, the weights of the following tissues were measured: breast muscle, leg muscle, abdominal fat, liver and heart.

Thirty samples of breast muscles (3 quails per treatment) were completely minced in a meat grinder and three samples were randomly collected and stored at -20°C for the next step to determine dry matter, protein and fat content using standard procedures (AOAC, 2000).

Table 1: Ingredients and chemical composition of basal diet

Ingredient	%
Maize	46.0
Soyabean meal	40.5
Fish meal	4.0
Oil	5.0
Oyster shell	1.40
Dicalcium phosphate	1.50
Salt	0.30
Methionine	0.15
Lysin	0.10
Mineral premix*	0.30
Vitamin premix**	0.30
Vitamin A	0.15
Vitamin B	0.15
Vitamin K3	0.15
Chemical analysis	
ME (kcal/kg)	3000
Crude protein (%)	24
Calcium (%)	1.09
Available Phosphorous (%)	0.51
Lysine (%)	1.57
Methionine (%)	0.55

* Mineral premix provided per kilogram of diet: Manganese, 80 mg; Copper, 10 mg; Iodine, 1 mg; Cobalt, 0.25 mg; Selenium, 0.3 mg; Zinc, 80 mg; Iron, 80 mg. ** Vitamin premix provided per kilogram of diet: Vitamin A, 9500 IU; Vitamin D3, 2500 IU; Vitamin E, 2 IU; Vitamin K3, 2 mg; Vitamin B12, 0.015 mg; Thiamin, 2 mg; Riboflavin, 6.8 mg; Follic acid, 1 mg; Biotin, 0.1 mg; Niaci, 30 mg; Pyridoxin, 5 mg; Pantothenic acid, 8 mg; Folic acid, 0.5 mg; Biotin, 0.15 mg; Choline chloride, 220 mg

Statistical design

Data were subjected to analysis of variance (ANOVA procedure) for a completely randomized design with a 2 × 5 factorial arrangement (SAS, 1993). Factors were gender (male and female) and Salbutamol (0, 1, 3, 5 and 7 mg/kg of diet). Means were compared using the Duncan's multiple range tests and the level of significance was set at 5%. The weight of birds at day 21 of the experiment was included in the model as a covariate effect for analysing weight gain, feed gain and FCR.

Results

No deaths were recorded in both sexes during the study. The effects of Salbutamol on body weight gain, food intake and food conversion ratio (FCR) are presented in Table 2. Weight gains in groups receiving Salbutamol were higher than those given control diet, but the differences were not statistically significant (P>0.05). Weight gain in males and females receiving a diet containing 7 mg Salbutamol/kg increased by 13 and 10 g, respectively compared to the control groups. Weight gain was higher in female than male (P<0.05). Gender, Salbutamol and their interactions had significant effects on food intake (P<0.01) and was highest in females than males and for 3 mg Salbutamol/kg diet. The lowest and the highest food intake were noticed for female quails fed the 7 and 3 mg Salbutamol/kg diet, respectively, while in males the lowest and the highest food intake belonged to the 1 and 3 mg Salbutamol/kg diet. Food intake decreased by 19.50 g in females and increased by 20.60 g in males fed the 7 mg Salbutamol/kg diet compared with the control diets. Salbutamol lowered food intake in females which was reflected in a statistically significant (P<0.01) Salbutamol × gender interaction.

Female quails had a better FCR than male quails (4.46 and 4.91, respectively, P<0.05). FCR was affected by Salbutamol administration, but the differences were not significantly different (P>0.05). It improved (lowered) the FCR compared with the control groups. It was lowest (better) for quails fed 7 mg Salbutamol/kg diets (4.54) and the highest (4.89) for quails fed control diets. There was no Salbutamol × gender interaction (P>0.05) for FCR, but the diet containing 7 mg Salbutamol/kg improved FCR in males and females compared to the control groups.

The influence of diets containing Salbutamol on the tissues and organs weight and the relative organs weight (g per 100 g of BW) are summarized in Table 3. The weight of breast, relative weight of breast

(P<0.01) and relative weight of leg (P<0.05) were influenced by Salbutamol administration. Abdominal fat weight was highest in birds fed the 7 mg Salbutamol/kg diet. Breast weight (P<0.01), relative weight of leg (P<0.01), liver weight (P<0.01) and leg weight (P<0.05) were influenced by gender. Breast weight, leg weight and liver weight were greater but relative weight of leg was lower in females. In contrast, the relative weight of breast, heart weight and abdominal fat weight were not statistically (P>0.05) different in male and female quails. In addition, the Salbutamol × gender interaction was only significant (P<0.05) for relative breast weight.

The influence of diets containing Salbutamol on the composition of breast muscle is presented in Table 4. The only parameter influenced by gender was percentage of moisture in breast muscle, which was higher (P<0.05) for females.

Discussion

The present study demonstrates the positive influence of Salbutamol on the repartitioning of protein and energy in the growth of quails. The increase in weight and relative weight of breast and leg weight in birds given diets containing Salbutamol indicated that it increased in protein deposition. The breast weight in female quails increased by 10.56% and the leg weight increased by 3.64% over male quails. Reduction in abdominal fat weight (for 1 and 3 mg Salbutamol/kg diets in both sexes) and breast muscle fat percentage are in agreement with previous reports that demonstrate that β-agonists exert a

Table 2: Influence of diets containing Salbutamol on body weight gain, food intake and food conversion ratio (FCR) in Japanese quails (21 to 49 days of age) (n=360)

Gender and diet	Weight gain (g)	Food intake (g)	FCR
Gender			
Male quails	142.5^{b}	699.4^{b}	4.91^{a}
Female quails	165.2^{a}	736.7^{a}	4.46^{b}
Diet			
Control	147.2	719.5^{b}	4.89
1 mg Salbutamol/kg diet	152.6	692.3^{c}	4.57
3 mg Salbutamol/kg diet	156.1	736.8^{a}	4.72
5 mg Salbutamol/kg diet	154.8	721.6^{b}	4.69
7 mg Salbutamol/kg diet	158.8	720.1^{b}	4.54
Gender × Diet			
Male control	136.6	695.3^{d}	5.08
Male × 1 mg Salbutamol/kg diet	135.6	656.8^{e}	4.84
Male × 3 mg Salbutamol/kg diet	149.0	717.2^{c}	4.81
Male × 5 mg Salbutamol/kg diet	141.8	711.8^{cd}	5.02
Male × 7 mg Salbutamol/kg diet	149.5	715.9^{c}	4.78
Female control	157.7	743.7^{ab}	4.71
Female × 1 mg Salbutamol/kg diet	169.6	727.8^{bc}	4.29
Female × 3 mg Salbutamol/kg diet	163.2	756.3^{a}	4.63
Female × 5 mg Salbutamol/kg diet	167.8	731.4^{bc}	4.35
Female × 7 mg Salbutamol/kg diet	168.0	724.2^{bc}	4.30
PSEM	4.29	5.10	0.11
Significance			
Gender	*	**	*
Salbutamol	NS	**	NS
Salbutamol × gender	NS	**	NS

Means with different superscript(s) within each column are significantly different. NS = Not significantly different (P>0.05). * Significantly different (P<0.05), and ** Significantly different (P<0.01). PSEM = Pooled standard error of the mean

Table 3: Influence of diets containing Salbutamol on the tissues and the average organs weight in Japanese quails (49 days of age) (n=90)

Gender and diet	Breast weight (g)	Breast weight (%)[1]	Leg weight (g)	Leg weight (%)[1]	Heart weight (g)	Liver weight (g)	Abdominal fat weight (g)
Gender							
Male quails	54.0^{b}	31.2	30.2^{b}	17.5^{a}	1.97	4.16^{b}	2.31
Female quails	59.7^{a}	31.0	31.3^{a}	16.3^{b}	1.93	6.37^{a}	2.50
Diet							
Control	51.5^{b}	29.3^{c}	30.0^{b}	17.1^{ab}	1.95	5.03	2.34^{ab}
1 mg Salbutamol/kg diet	57.6^{a}	30.5^{bc}	31.9^{a}	17.0^{abc}	1.90	5.19	1.74^{b}
3 mg Salbutamol/kg diet	56.4^{a}	30.9^{b}	30.0^{b}	16.5^{bc}	1.85	5.58	2.10^{ab}
5 mg Salbutamol/kg diet	59.6^{a}	32.7^{a}	31.5^{ab}	17.3^{a}	2.00	5.39	2.79^{ab}
7 mg Salbutamol/kg diet	59.1^{a}	31.7^{ab}	30.4^{ab}	16.4^{c}	2.03	5.12	3.06^{a}
Gender × Diet							
Male control	47.7	29.7^{b}	28.3	17.6	2.02	4.02	2.29
Male × 1 mg Salbutamol/kg diet	54.1	30.9^{b}	31.6	18.0	1.88	4.13	1.97
Male × 3 mg Salbutamol/kg diet	56.2	32.0^{ab}	30.3	17.3	1.94	4.36	1.94
Male × 5 mg Salbutamol/kg diet	56.6	31.6^{ab}	31.2	17.5	1.96	4.13	2.66
Male × 7 mg Salbutamol/kg diet	55.5	31.9^{ab}	29.5	17.0	2.03	4.17	2.71
Female control	55.6	29.3^{b}	31.7	16.7	1.88	6.04	2.38
Female × 1 mg Salbutamol/kg diet	61.2	30.3^{b}	32.3	16.0	1.92	6.26	1.52
Female × 3 mg Salbutamol/kg diet	56.5	29.9^{b}	29.7	15.7	1.77	6.81	2.26
Female × 5 mg Salbutamol/kg diet	62.7	33.8^{a}	31.7	17.2	2.05	6.65	2.91
Female × 7 mg Salbutamol/kg diet	62.8	31.7^{ab}	31.2	15.8	2.04	6.07	3.42
PSEM	0.79	0.26	0.30	0.01	0.03	0.16	0.16
Significance							
Gender	**	NS	*	**	NS	**	NS
Salbutamol	**	**	NS £	*	NS	NS	NS €
Salbutamol × gender	NS	*	NS	NS	NS	NS	NS

[1] Relative weights of organ (g/100 g BW). Means with different superscripts within each column are significantly different. NS = Not significantly different (P>0.05). * Significantly different (P<0.05), and ** Significantly different (P<0.01). PSEM = Pooled standard error of the mean. £: P=0.09. €: P=0.06

Table 4: Influence of diets containing Salbutamol on the chemical composition of breast muscle in Japanese quails (49 days of age) (n=30)

Gender and diet	Moisture (%)	Protein (%)	Fat (%)	Protein (% DM)[1]	Fat (% DM)[1]
Gender					
Male quails	66.53^{b}	25.78	5.11	77.56	15.32
Female quails	67.61^{a}	25.62	4.87	79.14	15.06
Diet					
Control	67.11	25.99	4.95	80.30	15.28
1 mg Salbutamol/kg diet	67.34	25.75	4.67	78.88	14.30
3 mg Salbutamol/kg diet	66.59	25.70	5.55	77.00	16.55
5 mg Salbutamol/kg diet	67.08	25.36	4.92	77.11	14.93
7 mg Salbutamol/kg diet	67.22	25.70	4.86	78.45	14.90
Gender × Diet					
Male control	66.26	25.55	5.31	78.03	16.23
Male × 1 mg Salbutamol/kg diet	66.90	26.09	4.45	78.93	13.36
Male × 3 mg Salbutamol/kg diet	66.39	25.16	4.08	74.90	17.96
Male × 5 mg Salbutamol/kg diet	66.38	25.79	4.95	76.76	14.70
Male × 7 mg Salbutamol/kg diet	66.73	26.32	4.74	79.16	14.33
Female control	67.96	24.63	5.49	77.40	15.33
Female × 1 mg Salbutamol/kg diet	67.79	25.41	4.90	78.83	15.27
Female × 3 mg Salbutamol/kg diet	66.80	26.25	5.02	79.10	15.15
Female × 5 mg Salbutamol/kg diet	67.78	24.93	4.88	77.46	15.17
Female × 7 mg Salbutamol/kg diet	67.72	26.07	4.98	79.03	15.46
PSEM	0.21	0.20	0.18	0.59	0.49
Significance					
Gender	*	NS	NS	NS	NS
Salbutamol	NS	NS	NS	NS	NS
Salbutamol × gender	NS	NS	NS	NS	NS

[1] DM = Dry matter. Means with different superscripts within each column are significantly different. NS = Not significantly different (P>0.05). * Significantly different (P<0.05), and ** Significantly different (P<0.01). PSEM = Pooled standard error of the mean

combination of both anabolic and lipolytic effects on animal production during their growth phase (NRC, 1994; Rehfeldt *et al.*, 1997). The fat percentage was decreased by 4.93% and protein content (in dry matter) was increased by 2.04% in the breast muscle of female quails over male quails (P>0.05). Salbutamol did not significantly affect the breast muscle composition, which is in agreement with the findings of Poornahavandi and Zamiri (2008) who reported that Ephedrin did not significantly affect the meat composition of fat-tailed Mehraban. 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 (Fennessy *et al.*, 1990; Zare Shahneh *et al.*, 2001). The decrease in carcass fat may be due to the inhibition of lipid synthesis (Duquett and Muir, 1982), while the reduction in the relative weight of abdominal fat may suggest the lipolytic activity (Wellenreiter, 1991). On the other hand, the increase in protein deposition may reflect decreasing protein degradation (Reeds *et al.*, 1986) caused by reduced Calpain I (a proteolytic enzyme) activity (Bardsley *et al.*, 1992).

Weight gain was affected (P>0.05) by Salbutamol and was higher in all Salbutamol-treated groups compared with the control groups. This result is consistent with some reports (Buyse *et al.*, 1991; Zamiri and Izadifard, 1995) but is not in agreement with others (Bakir *et al.*, 2001; Fawcett *et al.*, 2004). An improvement in weight gains in groups receiving Salbutamol-treated diets in the present study could be associated with the fact that beta-adrenergic compounds decrease degradation of protein (Forsberg and Merrill, 1986) and increase protein deposition (Grant *et al.*, 1990; Etherton and Smith, 1991). Beta-agonists may also decrease lipogenesis and increase protein synthesis, resulting in better energy utilization and higher weight gain (Mersmann, 2002). In this study weight gain was higher in females than males and increased by 15.92% in female quails. The highest and lowest weight gain were observed in male quails fed 7 and 1 mg Salbutamol per kg diets, respectively. In female quails, the highest and the lowest weight gain was observed in 1 mg Salbutamol per kg diet group and control group, respectively. Weight gain in males and females receiving the diet containing 7 mg Salbutamol/kg increased by 13 and 10 g, respectively compared to the control groups. These results are in agreement with the reports by Hamby *et al.* (1986) and Bakir *et al.* (2001) but are not consistent with other reports in broilers fed Salbutamol (Duquett *et al.*, 1988; Fawcett *et al.*, 2004). The differences in the results may be due to the differences in the type of β-agonist administered, species and duration of the treatment and interaction between these factors (Fennessy *et al.*, 1990). Food intake increased by 10.48% in females compared with males. The reason for the observed decline in food intake in females fed diets containing Salbutamol compared with the control group is unclear but may be due to the food intake suppressant effect of high doses of Salbutamol on the liver via a vagally mediated pathway (Howes and Forbes, 1987). Such an effect has not been reported in chickens given other β-agonists (Wellenreiter, 1991) nor has it been observed in pigs given diets containing Salbutamol (Cole *et al.*, 1987). Higher food intake and weight gain was linked to a better (lower) FCR in female quails. There was 9.16% improvement in FCR in female over male quails. The weights of the heart and liver of birds given diets containing Salbutamol were similar to those of the control groups (Table 3), which indicates that the addition of Salbutamol has no effect in this respect.

In summary, the results of the present experiment demonstrated that Salbutamol had beneficial effects on growth performance and carcass characteristics in Japanese quails. It seems that feeding 7 mg Salbutamol was more effective in female quails. However, due to public safety, more study is needed to determine the concentrations of Salbutamol in tissues of quails.

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