Effects of a beta-adrenergic agonist, Terbutaline, on carcass characteristics and performance of Cobb broiler chicks

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To study the effects of terbutaline on performance of broiler chickens, 21 d-old male and female Cobb broiler chicks (n=300) were randomly assigned to one of five dietary treatments containing 0 (control), 5, 10, 15 and 20 mg terbutaline per kg diet. The feed conversion ratio (FCR), feed intake and body weight gain were measured after 3 weeks. At 42-d age, six males and six females were randomly selected from each treatment and their live weight and weights of carcass, breast, breast muscle, drumsticks, drumstick muscle and abdominal fat were determined. Terbutaline didn't affect daily weight gain, but FCR of male chicks was reduced by 5 and 10 mg/kg terbutaline compared with the control group ($p<0.05$). Carcass weight and weight of drumsticks, drumstick muscle, breast, breast muscle and ratio of breast to live weight of female chicks receiving 5 mg/kg terbutaline were higher than for other treatments ($p<0.05$). In male chicks, the live weight and weight of carcass, ratio of carcass to live weight, drumsticks and drumstick muscle at 5 mg/kg terbutaline treatment were higher than for other treatments ($p<0.05$). This experiment showed that the addition of 5 mg terbutaline per kg diet during grower period improved FCR and ratio of carcass to live weight of male chicks; increased the ratio of breast to live weight of female chicks; and increased the carcass weight of male and female Cobb chicks.

Key words: Beta-adrenergic agonist; Terbutaline; Performance; Broiler Chicks

Introduction

As early as 1963, Cunningham reported on the effects of β-adrenergic agents on growth performance and carcass composition of chickens. Daily subcutaneous injection of epinephrine produced some stimulation of weight gain in Leghorns and broilers. The response was more pronounced in males than in females, and the response was observed to decrease as the dose increased. Carcass fat continued to decrease as the dose of epinephrine increased, probably as a result of the reduced body weights (Wellenreiter, 1991). Cimaterol on ducks and conturnix quail, and ractopamine on turkeys were studied. Also effects of $L_{644,969}$, [clenbuterol, sulbutamol and terbutaline], cimaterol, $L_{640,033}$ on broilers have been studied. Effects of cimaterol and isoprotrenol on protein metabolism of broiler have been reported. The growth promoting effects of these compounds might decrease with time and that administration of the compounds to birds later in the growth might be more beneficial. Almost all studies with β-agonists have been conducted with administration of the compounds occurring in the grower-finisher periods for the various species (Ansari et al, 2003).

Most β_2-agonists were originally developed for the treatment of bronchial diseases and as tocolytic agents. Later it was discovered that they were also efficient partitioning agents that promoted reduction in body fat and enhanced growth in cattle (Ricks et al., 1984), sheep (Baker et al., 1984; Beermann et al., 1987), and swine (Jones et al., 1985). To achieve these effects it is necessary to use doses that are approximately 10 times higher (Miller et al., 1988) than the common therapeutic dose. Similar studies with poultry demonstrated for the β_2-agonists an analogous metabolic action in decreasing carcass fat, and increasing protein deposition and carcass yield (Dalrymple et al. 1984; Duquette et al., 1988; Scholtyssek et al., 1988). Anabolic effects were also recognized in humans (Martineau et al., 1992).

The variation in responses may be due to the different mechanisms of action of the various β-adrenergic agonists in different species (Mersmann, 1987). Dalrymple *et al.* (1984) reported a significant increase in slaughter weight of broilers (sexes combined) fed clenbuterol up to 1 ppm from 28 to 49 days of age.

In several experiments conducted in United States and in Germany, concerning cimaterol supplementation to broiler chicks summarized by Dalrymple and Ingle and Scholtyssek, a consistent increase in weight gain was abserved. Also the β-adrenergic agonist $L_{340, 333}$ was found to increase weight gain of broilers (Muir et al., 1985; Duquette et al., 1988), Merkly and Cartright did not observe any effect of 0.25 ppm cimaterol on weight gain of broilers. Because the growth-promoting effect of β-adrenergic agonists is likely to be dependent on type, dosage, and possibly also on strain of broilers, those factors may account for the apparent discrepancies among published studies.

The degree of fat reduction by β-adrenergic agonists in broiler chicks was more evident in subcutaneous and meat fat than abdominal fat (Warriss *et al*., 1990; Zamiri and Ehsani, 1995).

In accordance with the effects of β-adrenergic agonists on fat deposition in all domestic animal species and in small laboratory animals, fat deposition was pronounced after prolonged supplementation with clenbuterol, indicating that, at least for this parameter, the clenbuterol effect is not transient. According to Merkly and Kartwright (1989), the fat-reducing properties of β-adrenergic agonists, at least in poultry, are more likely due to the reduction in adipocyte cell size than in adipocyte number.

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 animals (heifers). Rates of basal lipolysis were greater in subcutaneous adipose tissue from control heifers than from the heifers, treated with clenbuterol. Basal lipolysis in intramuscular adipose tissue was approximately 55% of the rate observed in subcutaneous adipose tissue (Miller et al., 1988).

Reduced carcass adipose tissue content could be the result of increased rates of lipolysis, decreased fatty acid and triglyceride biosynthesis, reduced adipocyte proliferation, or some combination of these events (Smith and Schiavetta, 1991). Insulin promotes fatty acid and glycerophosphate synthesis and inhibits hormone-sensitive lipase. It also activates lipoprotein lipase in liver and adipose tissue (Guyton, 1986).

The primary goal of this investigation was to study the effects of daily feeding terbutaline on carcass characteristics and skeletal (drumsticks and breast) muscle and abdominal fat.

Materials and methods

In this experiment, 600 broiler chickens (l-d-old) of the *Cobb* strain chicks were obtained from a local hatchery and all birds had free access to tap water and were given ad libitum access to a starter diet. At 21 d of age, 150 male and 150 female Cobb broiler chicks (n=300) were randomly assigned to one of five dietary treatments (CRD; 5 treatments and 2 sexes). From days 21 to 42 of the rearing period, terbutaline was fed (mixed in grower diet) daily at the rate of 0, 5, 10, 15 and 20 mg per kg of the predicted dietary intake. The amount of daily terbutaline was calculated on weekly basis according to the predicted feed intake for each week (NRC, 1994), to match 5, 10, 15 and 20 mg terbutaline per kg diet. Grower diet had 3.1 ME/kg and 22.3 % CP, consisting of 58% maize, 34% soybean meal, 4.2% sunflower oil and a vitamin and mineral supplement.

The feed conversion ratio (FCR), feed intake and body weight gain were measured after 3 weeks. At 42-d age, six males and six females were randomly selected from each treatment and their live weight and weights of carcass components were determined.

Data were analyzed by using the SAS program. The level of significance was set at P<0.05. If any significant effect of terbutaline treatment was noticed, means were compared by the Duncan's multiple range tests. Cold weight was included in the model as a covariate for analysis of variance of carcass data.

Results and discussion

Effect of terbutaline administration on the performance parameters and weight of various carcass components of the broiler chicks is shown in Tables 1 and 2.

Table 1 Effect of terbutaline on the performance parameters in male and female broiler chicks (Mean±SE)

Performance parameters	Sex	Terbutaline levels (mg/kg) 0	5	10	15	20	*P*
Weight gain (g/chick/d)	F	50.70±3.24	51.83±2.84	51.93±1.24	51.37±2.11	53.52±3.13	NS
	M	72.77±8.47	80.47±5.03	68.79±2.44	69.12±1.36	71.79±3.89	NS
Feed intake (g/chick/d)	F	113.91±5.29	118.55±4.95	128.57±5.66	107.64±2.68	114.82±4.74	NS
	M	162.71±10.9^{a}	146.78±11.1^{ab}	133.62±4.7^{b}	143.17±2.5^{ab}	147.02±3.82^{ab}	*
Feed conversion ratio	F	2.25±0.21	2.29±0.07	2.48±0.16	2.1±0.13	2.15±0.06	NS
	M	2.24±0.11^{a}	1.82±0.07^{b}	1.94±0.08^{b}	2.07±0.07^{ab}	2.05±0.06^{ab}	*
Carcass weight (g)	F	1091.2±14.6^{b}	1127.8±18.4^{a}	1086.5±15.9^{ab}	1106.5±14.8^{ab}	1086.4±15.5^{b}	***
	M	1321.6±19.9^{b}	1392.9±25.6^{a}	1324.9±18.7^{b}	1280.8±22.2^{C}	1364.2±20.2^{ab}	***
Carcass percent	F	67.59±0.85	70.09±0.95	68.22±0.96	68.65±0.4	67.86±1.03	NS
	M	69.03±0.58^{ab}	71.29±0.91^{a}	68.17±1.12^{b}	69.01±0.53^{ab}	70.34±0.82^{ab}	*
Live body weight (g)	F	1614.4±18.9	1609.2±26.1	1592.7±19.9	1611.9±18.6	1600.9±20.1	NS
	M	1914.6±20.1^{b}	1983.9±32.6^{a}	1943.6±19.7^{ab}	1855.9±29.3^{C}	1939.4±20.7^{ab}	***

a, b, c; within each row, means with a common superscript, do not differ at P<0.05 (*), P<0.01 (**) or P<0.001 (***).
NS: Not significant; SE: Standard error; P: Probability level

Table 2 Effect of terbutaline on the weight of various carcass components in male and female broiler chicks (Mean±SE)

Carcass components	Sex	Terbutaline levels (mg/kg) 0	5	10	15	20	*P*
Breast (g)	F	289.1±11.9^{b}	322.3±15^{a}	296.7±12.9^{ab}	286.1±12.1^{b}	270.8±12.7^{b}	***
	M	328.3±15.5	343.1±26.1	342.2±14.6	332.9±26.6	338.1±15.7	NS
Breast (%)	F	17.91±1.06^{ab}	20.03±0.94^{a}	18.63±0.3^{ab}	17.76±0.59^{ab}	16.92±0.47^{b}	*
	M	17.67±0.59	18.3±0.51	17.6±0.73	17.89±0.75	17.44±0.88	NS
Breast muscle (g)	F	252.3±10.5^{b}	286.6±13.3^{a}	257.4±11.5^{b}	247.6±10.6^{b}	236.5±11.2^{b}	**
	M	286.6±12.8	312.8±21.6	298.7±12	281.6±21.9	315.3±12.9	NS
Breast muscle (%)	F	15.64±1.04^{b}	17.81±0.98^{a}	16.16±0.34^{ab}	15.36±0.49^{b}	14.77±0.39^{b}	*
	M	14.97±0.51	15.77±0.42	15.37±0.71	15.13±0.91	16.26±0.13	NS
Drumstick (g)	F	349.4±6.3^{b}	361.9±8^{a}	358.5±6.9^{ab}	356.3±6.4^{ab}	358.4±6.8^{ab}	**
	M	431.2±10.2^{c}	473.2±9.8^{a}	438.3±9.6^{bc}	440.2±17.5^{bc}	453.5±10.3^{b}	**
Drumstick (%)	F	21.64±0.33	22.49±0.2	22.51±0.57	22.11±0.52	22.39±0.46	NS
	M	22.52±0.45	23.85±0.63	22.55±0.52	23.74±0.38	23.39±0.49	NS
Drumstick muscle (g)	F	238.9±6.4^{b}	256.5±8.12^{a}	251.5±7^{ab}	244.9±6.5^{ab}	244.9±6.8^{ab}	**
	M	293.1±7.2^{b}	322.7±12.2^{a}	298.7±6.8^{b}	299.8±12.3^{b}	315.5±7.4^{a}	***
Drumstick muscle (%)	F	14.8±0.43	15.94±0.22	15.79±0.58	15.19±0.45	15.3±0.36	NS
	M	15.31±0.42	16.27±0.53	15.37±0.46	16.16±0.22	16.27±0.35	NS
Abdominal fat (g)	F	25.8±5.1	20.3±6.5	29.9±5.6	32.4±5.2	36.1±5.5	NS
	M	35.8±2.9	29.4±4.9	28.6±2.7	28.5±5	30.5±2.9	NS
Abdominal fat (%)	F	1.6±0.24	1.26±0.2	1.88±0.36	2.2±0.39	2.25±0.21	NS
	M	1.87±0.27	1.48±0.26	1.47±0.25	1.54±0.19	1.57±0.18	NS

a, b, c; within each row, means with a common superscript, do not differ at P<0.05 (*), P<0.01 (**) or P<0.001 (***).
NS: Not significant; SE: Standard error; P: Probability level

Terbutaline didn't affect daily weight gain, but FCR of male chicks was reduced by 5 and 10 mg/kg terbutaline compared with the control group ($p<0.05$). Carcass weight and weight of drumsticks, drumstick muscle, breast, breast muscle and ratio of breast to live weight of female chicks receiving 5 mg/kg terbutaline were higher than for other treatments ($p<0.05$). In male chicks, the live weight and weight of carcass, ratio of carcass to live weight, drumsticks and drumstick muscle at 5 mg/kg terbutaline treatment were higher than for other treatments ($p<0.05$).

The ability of terbutaline (dose 5 mg/kg) to enhance some carcass components weight in the present study is consistent with the action of beta-agonists on mammalian skeletal muscle (Buttery and Dawson, 1987). The mode of action of beta-agonists on protein metabolism may be attributable to the inhibition of protein breakdown, because protein synthesis is not changed by beta-agonist in mammals (Buttery and Dawson, 1987; Garber et al., 1976) and chicks (Murmatsu et al., 1991).

It is important to note that some beta-agonists is capable of altering skeletal muscle gene expression, both quantitatively (i.e. more of each protein) and qualitatively (i.e. different contractile protein isoforms) and partially exerts its effects on muscle by inhibition of the degradation processes, but this probably does not occur as a direct inhibition of the activity of the proteases (Buyse et al., 1991).

β-adrenergic agonists by enhancement of satellite cell proliferation; stimulation of myofibrillar protein synthesis, depression of myofibrillar protein degradation and muscle hypertrophy enhance meat proteins (Smith and Schiavetta, 1991). Insulin promotes protein formation and also prevents the degradation of protein and it could be a reason for protein accumulation in meat (Guyton, 1986).

This experiment showed that the addition of 5 mg terbutaline per kg diet during grower period improved FCR and ratio of carcass to live weight of male chicks; increased the ratio of breast to live weight of female chicks; and increased the carcass weight of male and female Cobb chicks.

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