Introduction

Excessive carcass fatness in broiler chickens is now considered as an important problem for consumers and producers. A strong fat consumption certainly increases risks for cancer and cardiovascular diseases [9]. On the other hand, fat deposition can be influenced by environmental causes such as nutrition, as well as by genetic factors [10]. Genetic manipulations influence the fat quantity while nutrition factors affect both quantity and quality of fat. Therefore, an increased interest is focused on nutrition factors [12] and particularly on the effects of some food additives on fat metabolism.

Ractopamine hydrochloride (RAC) is used for altering fat metabolism and deposition, according to its lipolytic and growth promoter properties. Since 1963, β-adrenergic (β-AR) agonist was used in broiler diets, due to their effects on growth and carcass traits [5]. In 2003, the Food and Drug Administration approved the use of the β-AR agonist RAC in cattle and swine diets [21]. β-AR agonists efficiently modify growth and fat metabolism [14]. These drugs mediated protein turnover and muscle growth [18] and induced increases in blood glucose, lactate and insulin concentrations [1, 2, 13]. The aim of this study is to evaluate the RAC effects on growth performance and blood biochemical parameters, notably of lipid metabolism, in female broiler chickens.

Material and Methods

ANIMALS AND PROTOCOL DESIGN

One hundred eighty Ross female broiler chickens, 3 weeks old, randomly distributed into 12 pens were divided into 3 groups according to the dietary regimen. The trail was conducted using 3 x 5 completely randomized design for treatments (five replicates per treatment) with three dietary doses (0, 5 and 10 mg/kg) of ractopamine hydrochloride (Sinoway...
International Jiangsu, China) as the main effect. Ingredients and details of the designated diets are presented in Table I. Experimental diets were distributed to chickens for 3 weeks.

PERFORMANCE AND BIOCHEMICAL ANALYSES

Food intake, body weight gains and food conversion ratio were evaluated at the end of experiment. At the same time, 2 birds from each replicate were randomly sampled by jugular vein puncture. Blood samples were collected into sterile tubes without anticoagulant and after clotting for 12 hours at room temperature, samples were centrifuged (5000g for 10 minutes at room temperature) and sera were carefully harvested and stored at -20°C until analysis.

Serum concentrations of albumin, glucose, triglyceride, cholesterol, uric acid and BUN (Blood Urea Nitrogen) were measured by enzymatic methods using Darman Kave Diagnostics Kits (Res. Lab. Isfahan, Iran).

STATISTICAL ANALYSIS

Arcsine square transformation of data was carried out to achieve homogeneity of variance. Data processing was completed by the GLM procedure of the statistical program SAS [19]. Significant differences between main effects and their interactions were determined by least square means (LSMEANS) using a significant probability value ($P < 0.05$).

Results

Although growth and performance parameters (Food intake, weight gains and food efficiency) tended to gradually declined according to the RAC dose added to diets, the effects of the β-AR agonist on growth performance were not statistically significant (Table II).

The effects of dietary RAC supplementation on serum biochemical parameters are presented in Table III. Albumin and cholesterol concentrations were significantly depressed ($P < 0.05$) when ractopamine was added to the diet at 5 and 10 mg/kg whereas significant decrease in triglyceride concentrations ($P < 0.05$) was observed only with the highest dose (10 mg/kg). In addition, chickens receiving a diet enriched with 10 mg/kg RAC exhibited decreased BUN concentrations compared to the not supplemented birds ($P < 0.05$). Uric acid concentrations were also reduced compared to the controls proportionally to the RAC dose ($P < 0.05$). Finally, glycaemia was also significantly affected by the β-AR agonist supplementation ($P < 0.05$): compared to the controls, the glucose concentrations were significantly increased in birds treated with the highest RAC dose whereas this parameter was significantly decreased in animals treated with the lowest dose.

Discussion

The dietary supplementation with ractopamine in the present study has not induced significant growth effects in female broiler chickens although the weight gains tended to diminish and the food efficiency tended to be improved. This is in agreement with previous studies [3, 4]: indeed, BUYSE et al. [3] announced no significant effect of clenbuterol on weight gain and final body weight in broilers and according to CARTWRIGHT et al. [4] the addition of cimaterol into broiler diets did not improve body weight gains. In contrast, several researchers have shown some positive effects of β-AR agonists on growth rate [7, 17, 20, 25] and MERSMANN [15] reported an improvement in weight gains and food intake in

<table>
<thead>
<tr>
<th>Diet</th>
<th>Ractopamine (mg/kg)</th>
<th>1 (0 mg/kg)</th>
<th>2 (5 mg/kg)</th>
<th>3 (10 mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal portion¹</td>
<td>99.959</td>
<td>99.959</td>
<td>99.959</td>
<td></td>
</tr>
<tr>
<td>Ractopamine</td>
<td>0.000</td>
<td>0.0005</td>
<td>0.0005</td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td>0.041</td>
<td>0.0405</td>
<td>0.0400</td>
<td></td>
</tr>
</tbody>
</table>

¹Basal portion contained: 64.67% corn, 25.74% soybean meal (CP: 44%), 4.21% fish meal (CP: 60.05%), 2.737% soybean oil, 0.51% Dicalcium phosphate, 0.042% DL-methionine (Met), 0.20% salt, 0.15% Sodium bicarbonate, 0.25% mineral premix, 0.25% vitamin premix.

Vitamin and mineral premix includes the following ingredients per kilogram of diet: vitamin A (Vitamin A acetate) 4960 U; vitamin D (cholecalciferol) 1653 U; vitamin E (dl-α-tocopherol acetate) 27 U; menadione (menadione sodium bisulphate complex) 0.99 mg; vitamin B12 (cyanocobalamin) 0.015 mg; folic acid 0.8 mg; d-pantothenic acid (calcium pantothenate) 15 mg; riboflavin 5.4 mg; niacin (niacinamide) 45 mg; thiamin (thiamin hydrochloride) 1 mg; biotin 0.07 mg; pyridoxine hydrochloride 5.3 mg; manganese (manganeseoxide) 90 mg; zinc oxide 83 mg; iron sulphate monohydrate 121 mg; copper sulphate pentahydrate 12 mg; iodine (calcium iodate) 0.5 mg; selenium (sodium selenite) 0.3 mg.

Table I: Ingredients and composition of the experimental diets given to 3 week old female broiler chickens for 3 weeks.


In the present study, ractopamine addition to diets has significantly affected various serum biochemical parameters, suggesting efficient effects, particularly on glucose metabolism. β-AR agonists are usually known to increase glycaemia [2, 6, 13, 16] as observed in the present study with the highest dose (10 mg/kg) of ractopamine. It is admitted that this effect is linked to the direct amplification of gluconeogenesis [8, 23] coupled to the glycolysis inhibition [24] and also to the reduction of pancreatic insulin secretion [16]. MERSMANN [15] reported decreased insulin concentrations in blood from β-AR agonist treated sheep. However, the significant decrease in glycaemia observed in the present study with dietary 5 mg/kg RAC supplementation in female broilers compared to the not supplemented controls suggests complex and transient effects of β-AR agonists on the regulation of glucose metabolism; it is probable that the lowest dose was not sufficient to induce a durable and efficient blockage of insulin secretion for 3 weeks, and consequently glycaemia would globally decrease in response to abrupt and periodic releases of insulin. In addition, serum cholesterol and triglyceride concentrations were significantly increased in female broiler chickens supplemented with ractopamine in the present study, suggesting a shift in fat metabolism towards β-oxidation. In agreement with that, LIU et al. [11] has previously reported that ractopamine was effective in fat mobilisation. It is admitted that the β-AR agonist-induced insulin block is coupled to an increased activity of hormone sensitive lipases leading to enhancement of lipolysis and β-oxidation [17].

Changes induced by ractopamine supplementation in serum uric acid, BUN and albumin concentrations in the present study suggest its involvement in protein metabolism. Especially, the reduction in BUN and uric acid concentrations in RAC supplemented birds suggests sparing mechanisms in protein utilisation. Furthermore, the decline in albuminemia may also result for a preferential utilisation of this serum major protein in order to preserve other proteins [14]. Moreover, LIU et al. [11] reported increase in thigh percentage suggesting a stimulating effect of RAC on protein synthesis as previously evoked by VANDENBERG et al. [22].

As a conclusion, ractopamine supplementation has not significantly interfered with performance in female broiler chickens but it has significantly improved glucose and lipid mobilisation whereas protein utilisation may be spared.

**Acknowledgement**

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**References**


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